

GEODÆSIA:
OR, THE
ART of SURVEYING
AND
MEASURING LAND made Easy.

S H E W I N G
By plain and Practical **R U L E S**, to Survey, Pro-
tract, Cast up, Reduce or Divide any Piece of Land
whatsoever; with New **T A B L E S** for the Ease of
the Surveyor in Reducing the Measure of Land.

M O R E O V E R
A more Facile and Sure Way of Surveying by the **C H A I N**,
than has hitherto been taught.

A S A L S O
To lay out New Lands in **A M E R I C A**, or elsewhere: And how
to make a Perfect **M A P** of a River's Mouth or Harbour; with
several other Things never before Published in our Language.

By **JOHN LOVE.** *R*

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CORRECTED and IMPROVED
By **SAMUEL CLARK.**

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1771

GEODESIC



MEASURING

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Anthony Watts

THE
P R E F A C E
TO THE
R E A D E R.

IT would be ridiculous, to go about to praise an art that all mankind know they cannot live peaceable without, and is near hand as ancient (no doubt on it) as the world: for how could men set down to plant, without knowing some distinction and bounds of their land? But (necessity being the mother of invention) we find the Egyptians, by reason of the Nyle's overflowing,

The P R E F A C E.

ing, which either washed away all their bound-marks, or covered them over with mud, brought this measuring of land first into an art, and honoured much the professors of it. The usefulness, as well as the pleasant and delightful study, and wholesome exercise thereof, tempted so many to apply themselves thereto, that at length in Egypt (as in Bermudas) every rustic could measure his own land.

From Egypt, this art was brought into Greece by Thales, and was for a long time called Geometry ; but that being too comprehensive a name for the mensuration of a superficies only, it was afterwards called Geodæsia ; and what honour it still has continued to have among the antients, needs no better proof than Plato's *ἀγεωμετστοὶ ὅδ' εἰς εἰσὶν ἐτο*. And not only Plato, but most, if not all the learned men of those times, refused to admit any into their schools, that had not been first entered in the mathematics, especially geometry and arithmetic. And we may see, the great monuments of learn-

The P R E F A C E.

learning built on these foundations continuing unshaken to this day, sufficiently demonstrate the wisdom of the designers in chusing geometry for their ground-plot.

Since which, the Romans have had such an opinion of this sort of learning, that they concluded that man to be incapable of commanding a legion, that did not possess at least so much geometry, as to know how to measure a field. Nor did they indeed either respect priest or physician, that had not some insight into the mathematics.

Nor can we complain of any failure of respect given to this excellent science by our modern worthies, many noblemen, clergymen, and gentlemen affecting the study thereof: so that we may safely say, none but unadvised men ever did, or do now speak evil of it.

Besides the many profits this art brings to man, it is a study so pleasant, and affords such wholesome and innocent exercise, that we seldom find a man that has once entered himself into the study of

The P R E F A C E.

Geometry or Geodæsia, can ever after wholly lay it aside: so natural is it to the minds of men, so pleasingly insinuating, that the Pythagoreans thought the mathematics to be only a reminiscence, or calling again to mind things formerly learned.

But no longer to light candles to see the fun by, let me come to my business, which is to speak something concerning the following book; and if you ask, why I write a book of this nature, since we have so many very good ones already in our own language? I answer, Because I cannot find in those books many things, of great consequence, to be understood by the surveyor. I have seen young men in America so often at a loss, that their books would not help them forward; (particularly in Carolina,) about laying out lands, when a certain quantity of acres has been given to be laid out five or six times as broad as long. This I know is regarded as a mere trifle by a mathematician; yet to such as have no more of this learning, than to know how to measure

sure

The P R E F A C E.

sure a field, it seems a difficult question : and to what book of surveying shall they repair to be resolved ?

Also concerning the Extraction of the Square Root ; I wonder that it has been so much neglected by the teachers of this art, it being a rule of such absolute necessity for the surveyor to be acquainted with. I have taught it here as plainly as I could devise, and that by the best method now in use, using fewer figures, and being once well learned, charges the memory less than any other way.

Moreover, founding the entrance of a river or harbour is a matter of great import, not only to seamen, but to all such as seamen live by ; I have therefore done my endeavour to teach the young artist how to do it, and draw a fair draught thereof.

Many more things have I added, such as I thought to be new, and wanting ; for which I refer you to the book itself.

As for method, I have chose that which I thought to be the easiest for a learn-

The P R E F A C E.

er ; advising him first to learn some arithmetic, and after, teaching him how to extract the square root. But I would not have any neophyte discouraged ; for if he find the first chapter too hard for him, let him rather skip it, and go to the second and third chapters : those he will find so easy and delightful, that I am persuaded he will be encouraged to conquer the difficulty of learning that one rule in the first chapter.

From Arithmetic, I have proceeded on to teach so much Geometry as the art of surveying requires. In the next place, I have shewed by what measures land is surveyed, and made several tables for the reducing one sort of measure into another.

From thence I come to the description of instruments, and how to use them ; wherein I have chiefly insisted on the semicircle, it being the best that I know of.

The sixth chapter teacheth how to apply all the foregoing matters together, in the practical surveying of any field, wood, &c. divers ways, by various instruments ;
and

The P R E F A C E.

and how to lay down the same upon paper. Also at the end of this chapter I have largely insisted on, and by new and easy ways, taught surveying by the chain only.

The seventh, eighth, ninth, tenth and eleventh chapters, teach how to cast up the contents of any plot of land; to lay out new lands; also to survey a manor, county or country; and, how to reduce and divide lands, &c.

The twelfth chapter consists wholly of Trigonometry.

The thirteenth chapter treats of heights and distances, including, amongst other things, how to make a map of a river or harbour, and to convey water from a spring-head to any appointed place, or the like.

Lastly, at the end of the book, I have added a table of northing or southing, easting or westing; or, (if you please to call it so) a table of difference of latitude and departure from the meridian, with directions for the use thereof. Also a table of sines and tangents, and a table of logarithms.

I have

The P R E F A C E.

I have followed Mr. Holwell's method, in making the table of sines and tangents but to every fifth minute, that being near enough in practice for the surveyor's use ; for it is not possible with the best instrument that ever was yet made, to take an angle in the field nigher, if so nigh, as to five minutes.

All which I commend to the ingenious reader, wishing he may find benefit thereby, and desiring his favourable reception thereof accordingly. I conclude,

R E A D E R,

Your Humble Servant,

J. L.

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G E O D Æ S I A :

O R, T H E

Art of Measuring Land, &c.

C H A P. I.

Of A R I T H M E T I C.

IT is very necessary for him that intends to be an artist in the Measuring of Land, to be well acquainted with arithmetic, as being the groundwork and foundation of all arts and sciences mathematical; or at least not to be ignorant of the five first and principal rules thereof, viz. *Numeration, Addition, Subtraction, Multiplication, and Division*: which, supposing every Person that applies himself to the study of this art to be skilled in; or if not, referring him to Books or Masters (every where to be found) to learn: I shall name a sixth rule, as necessary (if not more) to be understood by the learner;

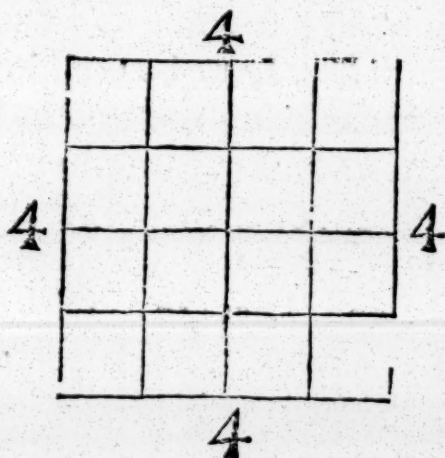
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which

which is the extraction of the square root ; without which (though seldom mentioned by surveyors in their writings) a man can never attain to a competent knowlege in the art : I shall not therefore think it unworthy my pains (though perhaps other men have better done it before me) to shew you easily and briefly how to do it.

To extract the Square Root of any given Number.

In the first place it is convenient to tell you what the square root is : it is to find out of any number propounded a less number, which number being multiplied in itself, may produce the number propounded. As for example : suppose 81 be a number given me, I say 9 is the root of it ; because 9 multiplied in itself, *viz.* 9 times 9 is 81. Now 8 could not be the root, for 8 times 8 is but 64 : nor could 10, for 10 times ten is 100 ; therefore, I say, 9 must needs be the root, because multiplied in itself, it makes neither more nor less than the number propounded, *viz.* 81.



Again: suppose 16 be the number given, I say the root of it is 4, because 4 multiplied in itself makes 16. For your better understanding see this figure, which is a great square, containing 16 little squares ; any side of which great square contains 4 little squares :

which is called the square root.

Or,

Of Arithmetic.

3

Or, suppose a plain square figure be given you, as this in the margin, and it be required of you to divide it into 9 small squares; your business is to know into how many parts to divide any one of the side lines, which here must be into 3, and that is the root required.



But how to do this readily is the thing I am now going to teach you. The roots of all square numbers under 100, you have in your multiplication table; however, since it is good for you to keep them in your mind, take this small table of them.

Roots	1	2	3	4	5	6	7	8	9
Squares	1	4	9	16	25	36	49	64	81

Here you see the root of 25 is 5, the root of 64 is 8, and so of the rest.

So far as 100 in whole numbers, your memory will serve you to find the root; but if the number propounded, whose root you are to search out, exceed 100, then put a point over the first figure on the right hand, which is the place of units, and so proceeding to the left hand, miss the second figure, and put a point over the third; then missing the fourth, point the fifth; and so (if there be ever so many figures in the number) proceed on to the end, pointing every other figure, as you may see here, and so many points as there are,

of so many figures your root will consist, which is very material to remember: then begin at the first figure on the left hand that has a point over it, which will always be

12[.]34[.]56[.]7[.]

the first or second figure, and search out the root of the one figure, or both joined together if there be two; and when you have found it or the highest less to it, which you may easily do by the table above, or your own memory, draw a little crooked line, as in division, and there set it down; then square that root or quotient, (that is multiply it by itself) and set it under the first square; draw a line and subtract; to this remainder bring down the next period, or pair of figures; double the root, and place it on the left hand for a divisor, then see how often the divisor can be held in the resolvend, (excepting the figure to the right hand) and as often as you find it will go, place it in the root, and also in the unit's place of the divisor; multiply the last root by the divisor, and place the product under the resolvend; continue thus till all the periods or square numbers be brought down, and if any thing remains, add two cyphers, and work as has been taught above; and for every two cyphers thus added, there will be one decimal place in the root.

E X A M P L E.

To extract the square root of 99856. Point it as before shewn, and it will stand thus $\dot{9}9\dot{8}5\dot{6}$; then seek a number whose square shall be equal to the first figure 9, viz. 3, and write it in the root or quotient; then having subtracted from 9, 3 by 3, or 9, there will remain 0: to which set down the figures as far as the next point, viz. 98, for the following operation:

Then

Of Arithmetic.

5

Then taking no notice of the last figure 8, say, how many times is the double of 3 (or 6) contained in the first figure 9?

Answer, 1. Wherefore having set 1 in the root, subtract the product of 1 by 61, or 61 from 98, and there will remain 37; to which connect the last figures 5 6, and you will have the number 3756, in which the work is next to be carried on; wherefore,

$$\begin{array}{r} 99856 \quad (316 \\ 9 \\ \hline 098 \\ 61 \\ \hline 3756 \\ 3756 \\ \hline \end{array}$$

also neglecting the last figure of this, viz. 6, say, How often is the double of 31, or 62, contained in 375 (which may be guessed at from the initial figures 6 and 37, by taking notice how many times 6 is contained in 37?) Answer, 6; and writing 6 in the quotient, subtract 6 by 626 or 3756, and there will remain 0; whence it appears that the business is done, the root coming out 316.

Otherwise, with the divisors set down, it will stand thus:

$$\begin{array}{r} \cdot \cdot \cdot \\ 99856 \quad (316 \\ 9 \\ \hline 61)098 \\ 61 \\ \hline 626)3756 \\ 3756 \\ \hline \end{array}$$

Again, if you were to extract the root out of 22178791: First, having pointed it, seek a number, whose square, (if it cannot be exactly equalled)

B 3

shall

shall be the next less square (or nearest) to 22, the figures to the first point, and you will find it to be 4 : for 5 by 5, or 25 is greater than 22, and 4 by 4, or 16 is less : wherefore 4 will be the first figure of the root. This, therefore, being writ in the quotient, from 22 take the square 4 by 4, or 16, and to the remainder 6, adjoin the next period of figures 17, and you will have 617 ; ~~x~~ from whose division, by the double of 4, you are to obtain the second figure of

the root, (viz. 7,) as thus : neglecting the last figure 7, say, How many times 8 is contained in 61 ? Answer, 7 ; wherefore write 7 in the quotient, and from 617 take the product of 7 ~~into~~ 87, or 609, and there will remain 8 ; to which join the two next figures 87, and you will have 887 ; by the division whereof, by the double of 47, ^{or} 94, you are to obtain the third figure ; in order to ^{which} say, How many times is 94 contained in 88 ? Answer, 0 ; wherefore write 0 in the quotient, and bring down the two last figures 91, and you will have 88791, by whose division by the double of 470, or 940, you are to obtain the last figure ; thus I say, How many times 940 in 8879 ? Answer 9 ; wherefore write 9 in the quotient, and you will have the root 4709. But, since the product 9 by 9409, or

$$\begin{array}{r}
 22\dot{1}7879\dot{1} \text{ (4709.43637, \&c.)} \\
 \underline{16} \\
 617 \\
 \underline{609} \\
 88791 \\
 \underline{84681} \\
 411000 \\
 \underline{376736} \\
 3426400 \\
 \underline{2825649} \\
 60075100 \\
 \underline{56513196} \\
 356190400 \\
 \underline{282566169} \\
 73624231
 \end{array}$$

84681,

x neglecting the last figure 7

84681, subtracted from 88791, leaves 4110, the number 4709 is not the complete root of the number 22178791, but a little less.

If then it be required to have the root approach nearer, carry on the operation in decimals, by annexing to the remainder two cyphers in each operation. Thus the remainder 4110, having two cyphers added to it, becomes 411000; the division whereof by the double of 4709, or 9418, you will have the first decimal figure 4. Then having writ 4 in the quotient, subtract 4 by 94184, or 376736, from 411000, and there will remain 34264. And so having added two more cyphers, the work may be carried on at pleasure, the root at length coming out 4709,43637, &c.

But when the root is carried half way or above, the rest of the figures may be obtained by division alone; as in this example, if you had a mind to extract the root to nine figures, after the five former 4709,4 are found, the four latter may be found, by dividing the remainder, viz. 342640, by the double of 4704,4.

After the same manner are roots extracted out of decimal numbers,—Thus, the root of 329,76 is 18,159: and the root of 3,2976 is 1,8159, and the 0,032976 is 0,18159, and so on. But the root of 3297,6 is 57,4247; and the root of 32,976 is 5,74247. And thus the root of 9,9856 is 3,16.

There are other ways taught by arithmeticians for finding the square root of any number; but I know no way so concise as this, and after a little practice, so easy and ready or to be wrought with as few figures. To do it indeed by the logarithms, or artificial numbers, is very easy and pleasant; but sur-

veyors have not always books of logarithms about them when they have occasion to extract the square root ; however, I will briefly shew you how to do it, and give you one example thereof.

When you have any number given whose square root you desire, seek for the given number in the table of logarithms under the title numbers ; and right against it under the title logarithms, you will find the logarithm of the said number, the half of which is the logarithm of the root desired : which half seek for under the title logarithm, and right against it under the title number, you will find the root.

E X A M P L E.

Let 625 be the number whose root is desired. First, I seek for it under the title numbers, and right against it I find this Log. 2795880, which I divide by 2, or take the half of it 1,397640, as you see : and finding that half under the title Log. right against it is 25, the root desired. See the same done by the former way with less trouble.

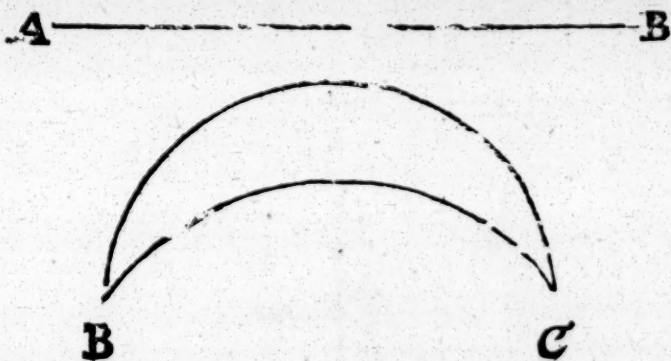
$$\begin{array}{r}
 \begin{array}{c} \cdot \cdot \\ 625 \end{array} (25 \\
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 45 \overline{)225} \\
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C H A P. II.

GEOMETRICAL DEFINITIONS.

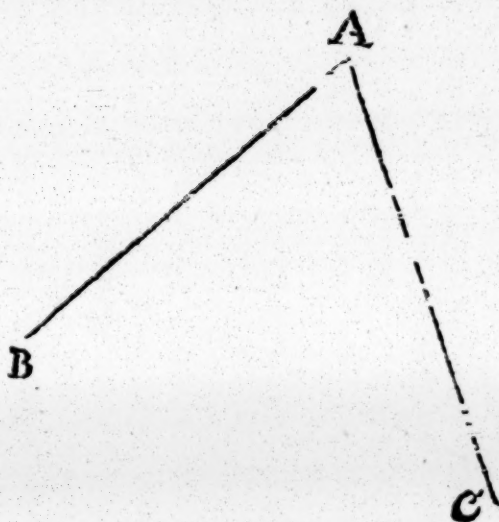
A Point is that which has no parts ; consequently of itself no magnitude, and may be considered as indivisible. It is commonly marked as a full stop in writing, thus (.)

A line has only length, but neither breadth or thickness, and may be conceived as generated by the continual motion of a point. There are two sorts of lines, viz. strait and crooked ; as *A B* is a strait line, *B C* two crooked lines.



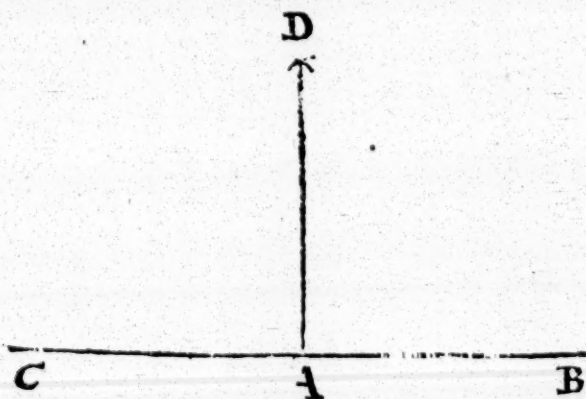
An angle is the meeting of two lines in a point ; provided the two lines so meeting do not make one strait line, as the line *A B*, and the line *A C*, meeting together in the point *A*, form the angle *B A C*.

Of



Of right-lined angles there are three sorts, viz. right-angled, acute, and obtuse.

When a line falleth perpendicularly upon another line, it maketh two right angles.



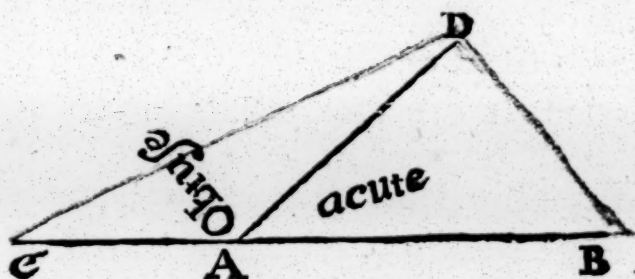
E X A M P L E.

Let CAB be a right line, DA a line perpendicular to it, that is to say, neither leaning towards B nor C , but exactly upright; then are both the angles at A , viz, DAB , and DAC , right angles; and

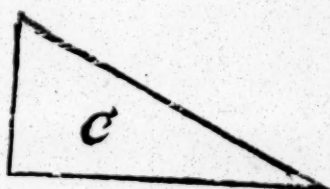
Geometrical Definitions.

II

and contain each just 90 degrees, or the fourth part of a circle: but if the line DA had not been perpendicular, but had leaned towards B, then had DAC been an obtuse angle; or greater than a right angle; and DAB an acute angle, or less than a right angle, as you see hereunder.



All figures contained under three sides are called triangles, as A, B, C.



Where note, when a triangle as A hath three equal sides, it is called an equilateral triangle.

The triangle B hath only two sides equal, and is therefore called an isosceles triangle.

The triangle C hath the three sides unequal, and is called a scalene triangle.

Of

Of four-sided Figures there are these Sorts.

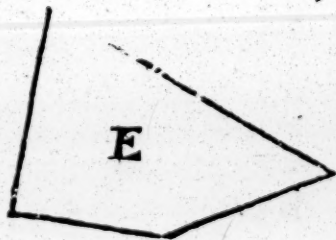
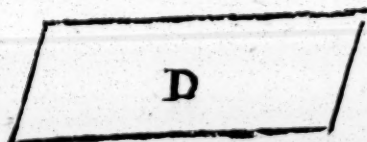
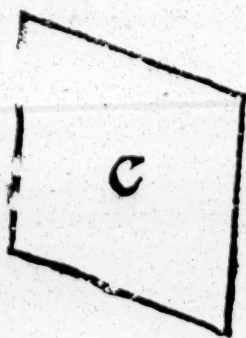
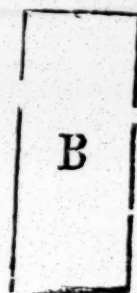
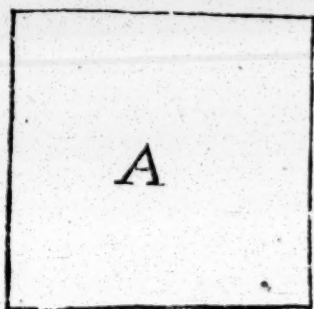
First, A square whose sides are all equal, and angles right, as A.

Secondly, A long square, or right-angled parallelogram, whose opposite sides are equal, and angles right, as B.

Thirldly, A rhombus, whose sides are all equal, but no angle right as C.

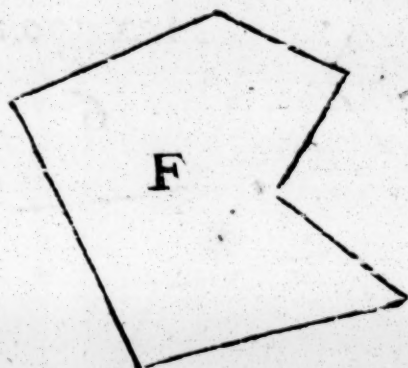
Fourthly, A rhomboides, whose opposite sides only are equal, and no right angles, as D.

All other four-sided figures are called trapezia ; thus E is a trapezium.



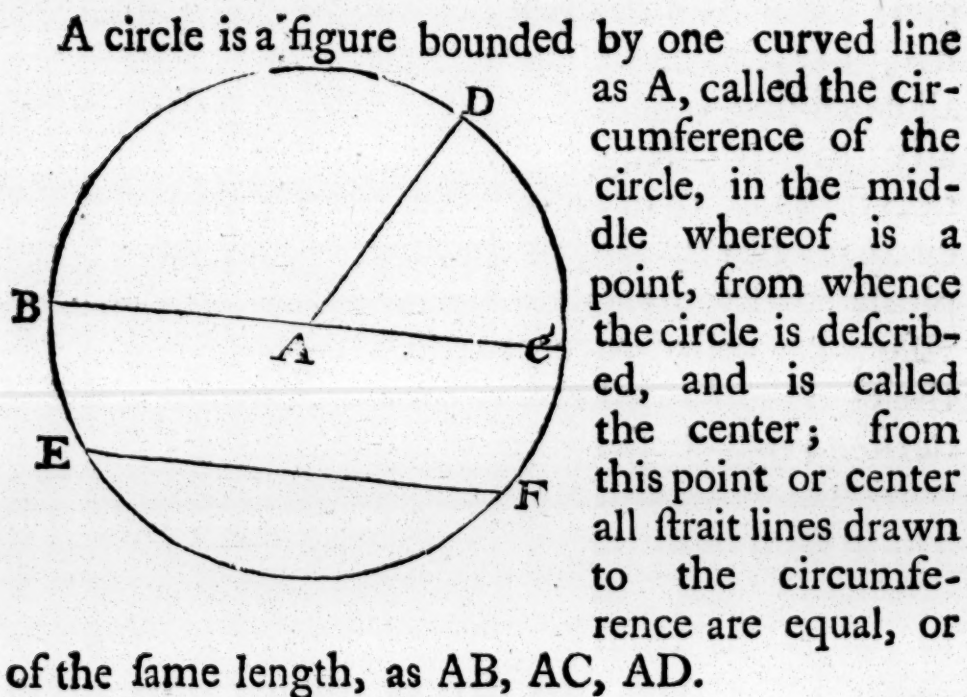
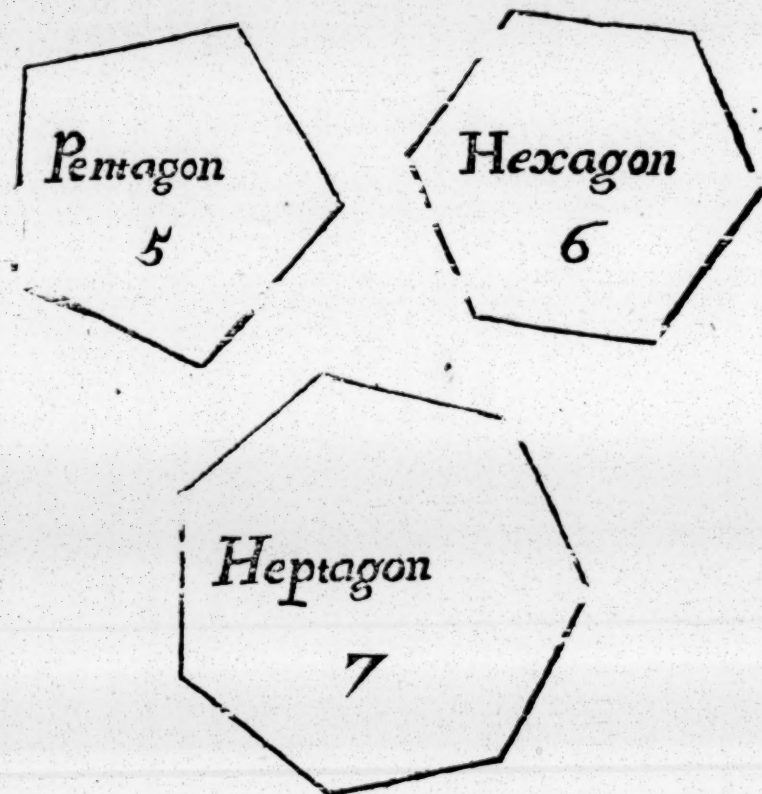
Other

Other figures that are contained under 5, 6, 7, or more sides, I call irregular, as F, &c. except



such as are made by dividing the circumference of a circle into any number of equal parts; for then they are regular figures, having all the sides and angles equal; and are called according to the number of equal parts the circle is divided into, or more properly according to the number of angles they contain, as a pentagon, hexagon, heptagon, octagon, &c. Which signifies no more than a figure of five, six, seven, or eight angles; these angles are all equal one to another, and their sides consequently all of the same length. And thus (though I mention no more than eight) the circumference of the circle may be divided into as many equal parts as you please; and the regular figures formed by such divisions are called according to the number of parts the circle is divided into. See, for your better understanding, these two or three following:

A circle



of the same length, as AB, AC, AD.

The

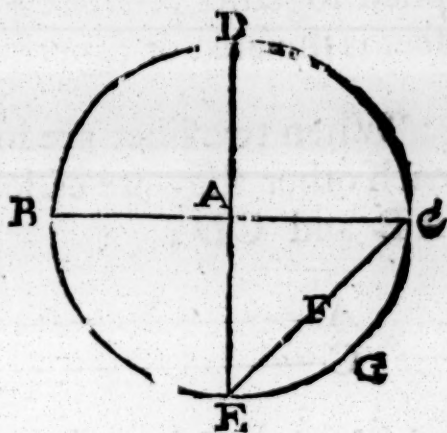
The diameter of a circle is a line as BC , which passing through the center, cuts the circle into two equal parts, or it is the longest strait line that can be drawn in any circle.

The femidiameter, or the radius is the half of the abovementioned line, as AB , AC , or AD , either of which is called a femidiameter.

A chord is any line shorter than the diameter, which passeth from one part of the circumference to another, as EC .

A semi-circle is the half of a circle, as BDC , or $BE C$.

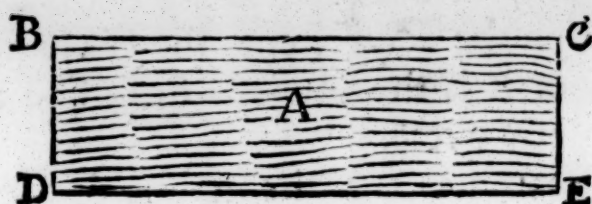
A quadrant is the fourth part of a circle, made by two diameters perpendicularly intersecting each other, as ABD , ADC , ABE , AEC , either of which is a quadrant or the fourth part of a circle.



A segment of a circle is a part of the circle cut off by a chord line, and may be either greater or less than a semi-circle. Thus $EFCG$ is the lesser segment, and $EBDCF$ the greater segment of the same circle $EBDCGE$.

A superficies is that which hath both length and breadth, but no thickness; whose bounds are right lines, as A is a superficies or plane, contained by the lines, BC , DE , BD , and CE , whose length is BC , and breadth BD .

When

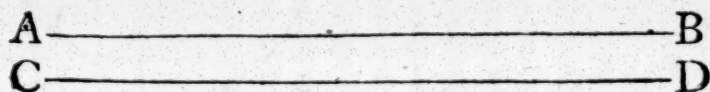


When these bounding lines (at right angles to each other) are measured, and the content of the superficies cast up, the result is called the area or superficial content of that figure.

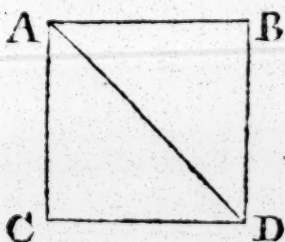
E X A M P L E.

Suppose the line BC to be twelve feet in length, and the line BD to be four feet long, these multiplied together produce 48; therefore I say, 48 square feet is the area or superficial content of that figure.

When two lines are in every part equidistant from each other they are called parallel lines, as the lines AB and CD ;



which though produced to ever so great a length, would come no nearer to each other, and consequently never meet.



A diagonal line is a line running through a square figure, dividing it into two equal triangles, beginning at one angle of the square, and proceeding to the opposite angle. In the square $ABCD$, AD is the diagonal line.

CHAP.

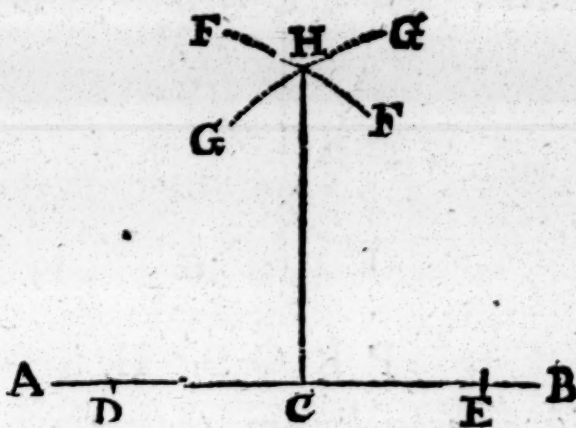
C H A P. III.

GEOMETRICAL PROBLEMS.

P R O B. I.

To draw a line perpendicular to a given line from a point therein assigned.

THE line given is AB, and at the point C, it is required to erect a line which shall be perpendicular to AB.



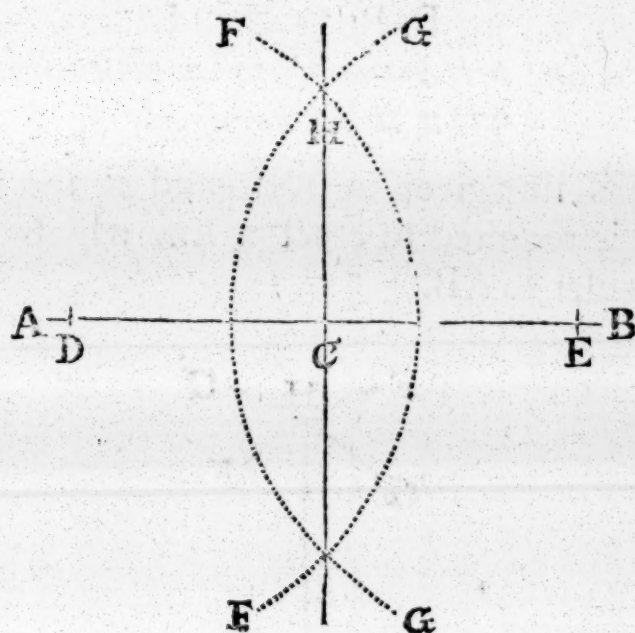
Open your compasses to any convenient wideness, and setting one foot of them in the point C, with the other make a mark upon the line at E, and also at D; then taking off your compasses, open them a little wider than before, and setting one foot in the point D, with the other describe the arch FF; then, without altering your compasses, set one foot in the point E, and with the other describe the arch GG.

C

Lastly,

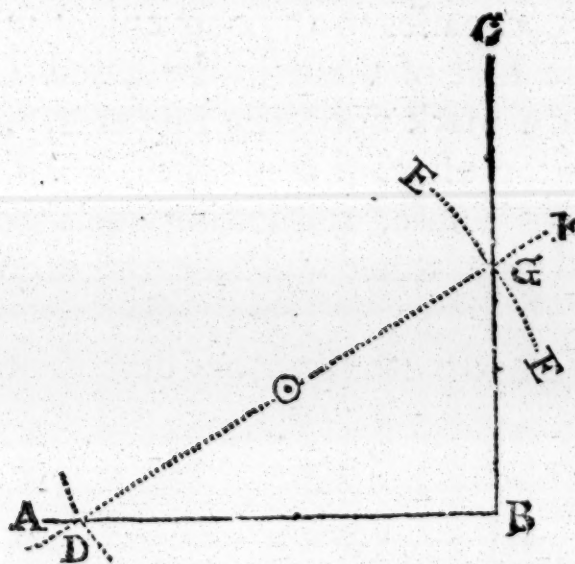
Lastly, lay your ruler to the point C, and the intersection H of the two arches GG and FF; then draw the line HC, you have your desire, HC being perpendicular to AB.

See it here done again after the very same manner, but perhaps plainer for your understanding.



P R O B. II.

To raise a perpendicular upon the end of a line.

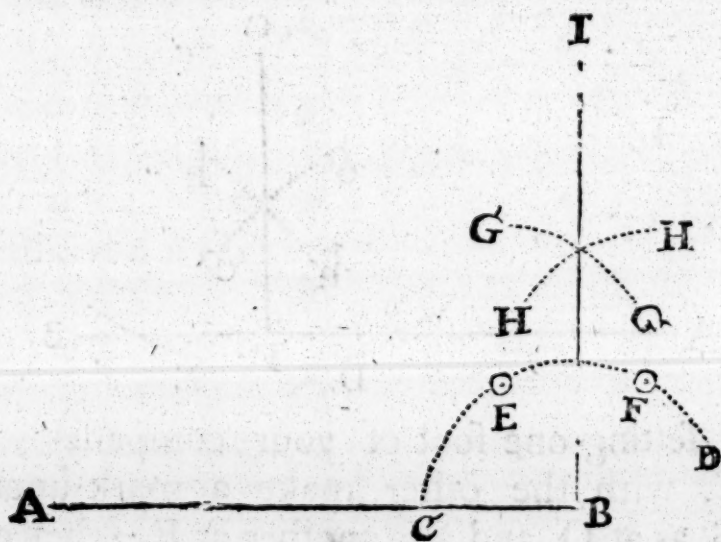


A B is the line given, and at B it is required to erect a perpendicular, as B C.

Open your compasses to an ordinary extent, and setting one foot in the point B, let the other fall at adventure, no matter where in reason, as at the point $\odot$; then without altering the extent of the compasses, set one foot in the point $\odot$, and with the other cross the line A B, as at D: also on the other side describe the arch E E; then laying your ruler to D and $\odot$, draw the dotted line D $\odot$ F. Lastly, from the point B, you began at, through the intersection G, draw the line BGC, which will be perpendicular to A B.

Another way, I think rather more easy, though indeed nearly the same.

Let A B be the given line.

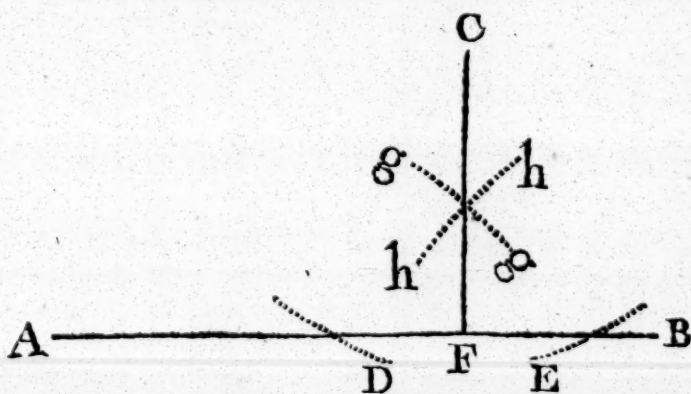


Set one foot of your compasses in B, and with the other at any ordinary extent, describe the arch CEFD; then keeping your compasses at the same extent, set one foot in C, and make a mark upon the arch at E; and keeping one foot in E, make another mark at F; then with any extent set one foot in E, and with the other describe the arch GG; also setting one point in F, make the arch HH, then draw a right line, as I B, through the intersection of those arches, and the point first proposed, it will be the perpendicular required.

P R O B. III.

From a point assigned, to let fall a perpendicular upon a line given.

The line given is AB, the point is at C, from which it is desired to draw a right line down to AB, that it may be perpendicular to it.



First setting one foot of your compasses in the point C, with the other make a mark upon the line AB, as at D, and also another at E; then opening your compasses wider, or shutting them closer, either will do; set one foot in the point of intersection

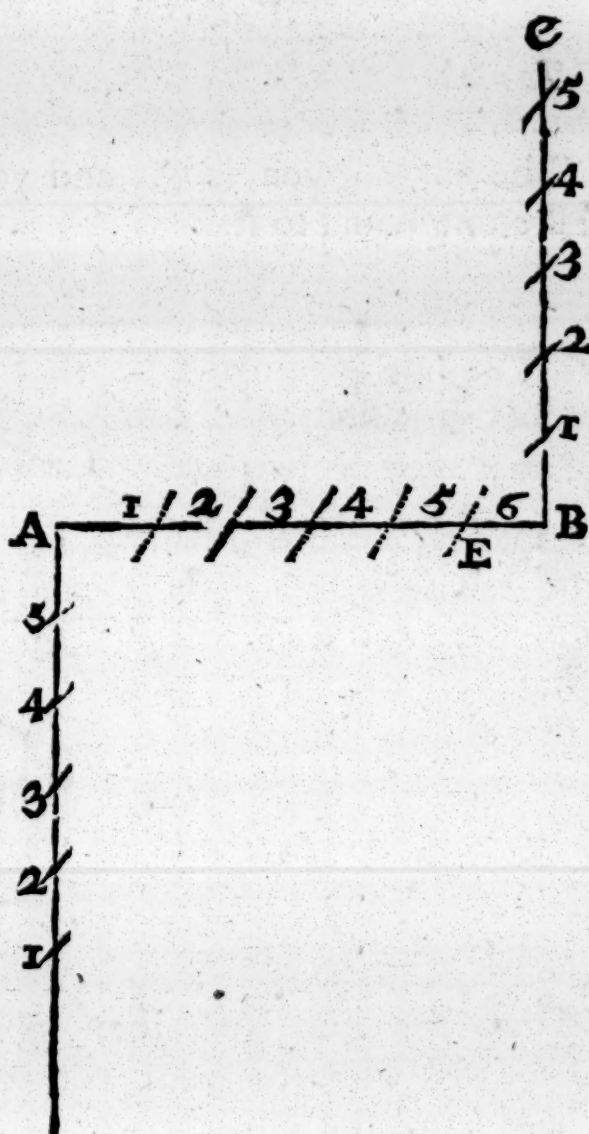
tersection at D, and with the other describe the arch *gg*; do the like at E, for the arch *bb*. Lastly, From the point assigned, through the point of intersection of the two arches, *gg* and *bb*, draw the perpendicular line CF.

P R O B. IV.

To divide a line into any number of equal parts.

AB is a line given, and it is required to divide it into 6 equal parts.

Make at the point B a line perpendicular to AB, as BC: do the same at A, the contrary way, as you see here; open your compasses to any convenient wideness, and upon the lines BC and AD, mark out five equal parts; for it must be always one less than the number you intend to divide the line into: which parts you may number as you

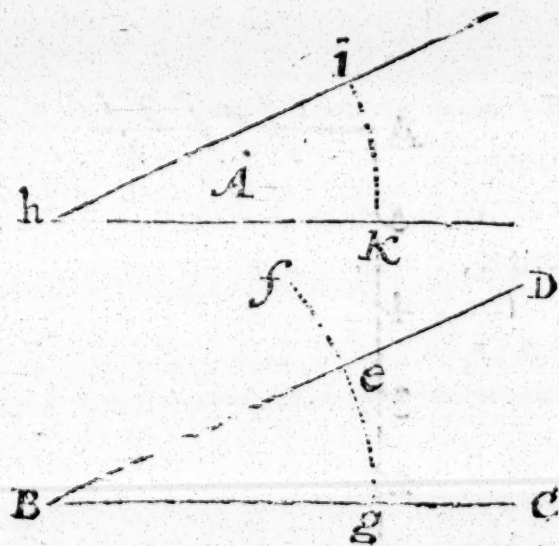


see here, those upon one line one way, and the other the contrary way; then laying your ruler from N^o. 1. on the line BC, to N^o. 1. on the line AD, it will intersect the line AB at E, which you may mark with your pen, and the distance between B and E is one sixth part of the line; so proceed on 'till you come to N^o. 5. and then you will find that you have divided the given line into six equal parts, as required.

P R O B. V.

To make an angle equal to any other angle given.

The angle given is A, and you are desired to make one equal to it.



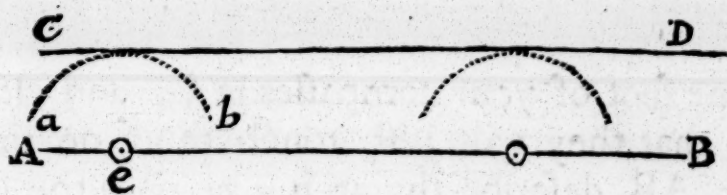
Draw the line BC, then going to the angle A, set one foot of your compasses in the point h, and with the other at what distance you please, describe

describe the arch IK ; then without altering the extent of the compasses, set one foot in B , and draw the arch fg ; after that measure with your compasses how far it is from K to I , and the same distance set down upon the arch from g towards f , which will fall at E ; draw the line BED , and the angle DBC will be equal to the given angle A .

P R O B. VI.

To draw lines parallel to each other.

AB is a line given, and it is required to draw a line parallel to it.

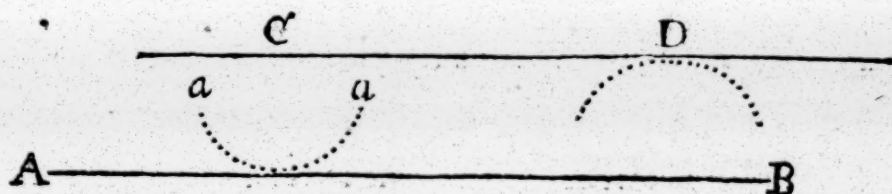


. Set one foot of your compasses at or near the end of your given line, as at E , and with the other describe the arch ab ; do the same near the other end of the said line; then draw the line CD , just to touch the convexity of those arches, and it will be the parallel required.

P R O B. VII.

To draw a line parallel to another line, which shall also pass through a point assigned.

Let AB be the given line, C the point through which the required parallel line must pass.



Set one foot of your compasses in C, and closing them so that they will just touch (and no more) the line AB, describe the arch *a a*; with the same extent in any part of the given line set one foot, and describe another arch, as at D; then through the assigned point C, draw a right line CD, just to touch the convexity of the last described arch, and it will be parallel to AB, as was required.

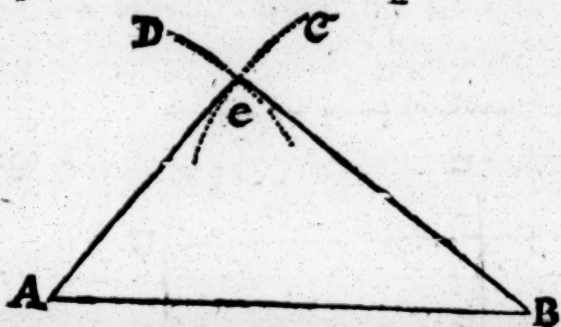
P R O B. VIII.

To form a triangle with three given right lines, provided any two of these lines, taken together, be longer than the third.

Let the three lines given, be those marked 1, 2, 3, in the next figure.

Take

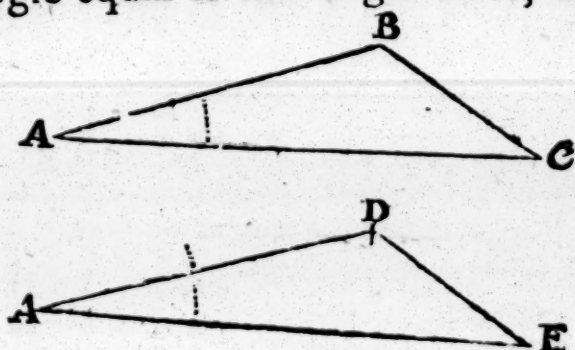
Take with your compasses the length of either of the three in this 1— example: let it be 2— that No. 1. viz. 3— the longest, and lay it down as hereunder from A to B; then taking with your compasses the length of the line 2, set one foot in B, and make the arch C; also taking the length of the last line 3, place your compasses at A, and describe the arch D, which will intersect the arch C in the point e; from this point of intersection draw right lines to the points A B, which shall constitute the triangle A e B; the line A B being equal to the line N^o. 1. B e to N^o. 2, and A e to N^o. 3.



P R O B. IX.

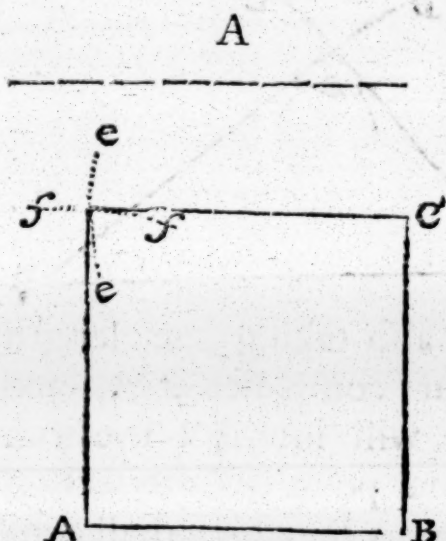
To make a triangle equal and equiangular to a triangle given.

First make an angle equal to the angle at A, as you were taught in *Prob. 5*. Then making the lines A D and A E respectively equal to A B and A C, draw the line D E.



P R O B. X.

To describe a square figure upon a given right line.



Let A be a line given, and it is required to make a square figure thereon.

First, Lay down the length of your line A, as A B.

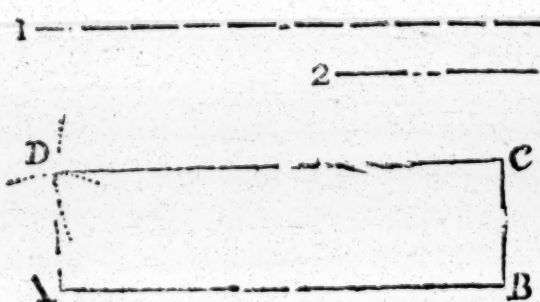
Secondly, Raise B C perpendicular and equal to B A.

Thirdly, Take the length of either of the aforementioned lines with your compasses, and setting one foot in C, describe the arch *ee*; do the like at A, and describe the arch *ff*.

Fourthly, Draw lines from A and C to the point of intersection, and the square is finished.

P R O B. XI.

To make a right-angled parallelogram, or long square.



This is much like the former. Admittwo lines be given, as 1, 2, and it is required to make a parallelogram of them: what I a parallel-

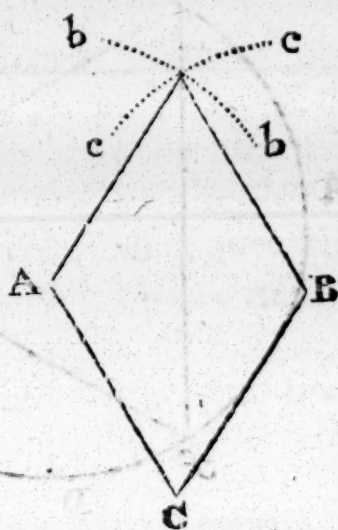
a parallelogram is, you may see in the second chapter of *Definitions*.

First, Lay down your longest line, as AB , upon the end B of which erect a perpendicular line, equal in length to your shortest line; and so proceed, as you were taught in the foregoing problem.

P R O B. XII.

To describe a rhombus.

First, Make an angle, ACB , of any magnitude at pleasure with two equal lines, as AC and BC ; then taking one of these lines in your compasses, set one foot in A , and describe the arch bb ; also set one foot in B , and describe the arch cc . Lastly, draw lines from A and B to the point of intersection, and it is finished. The two equilateral triangles together, form a rhombus.

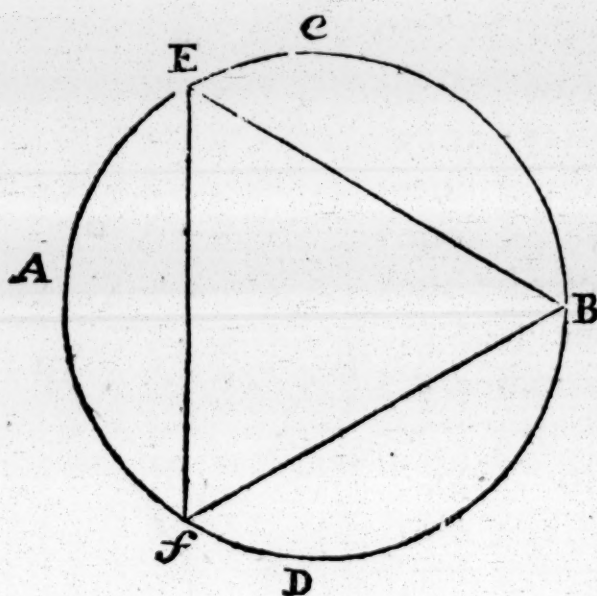


A rhomboides differs from a rhombus, as a right-angled parallelogram does from a square; it being no other than an oblique parallelogram, and therefore it is needless to give its description.

P R O B. XIII.

To divide a circle into any number of equal parts, not exceeding ten, and also to shew how the figures called, Pentagon, Hexagon, Heptagon, Octagon, &c. may be described.

Let ABCD be a circle, in which it is required to inscribe an equilateral triangle, being the greatest that can possibly be made therein.



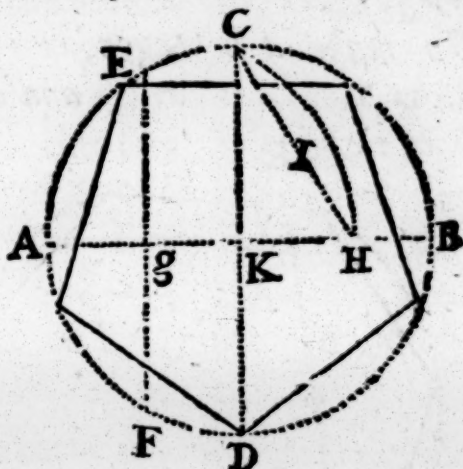
Keeping your compasses at the same extent they were at when you made the circle, set one point of them in any part of the circumference, as at A, and with the other make a mark at E, and also at f; then draw a line

for E to f, which will be one side of the triangle.

I need not tell you how to make the other two sides, for as it is an equilateral triangle, all three sides will be of equal length.

To make a pentagon, or five-sided figure.

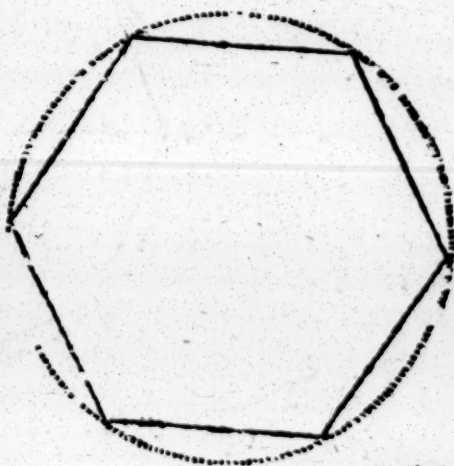
Draw first an obscure circle, as $A C B D$; then draw a diameter from A to B ; make another diameter CD perpendicular to the first; then taking with your compasses the length of the semidiameter, set one point in A , and make the marks E, F , drawing a line between them, as you did



to make a triangle. Next, set one point of your compasses in the intersection at g , and extend the other to C , draw the arch CH : and the chord of this arch, *viz.* the line CIH , will be the side of a pentagon, and the greatest five-sided figure that can be made within that circle. With this extent of your compasses, you may mark out five points round the circle, and joining those points with right lines, the figure will be finished.

To make a hexagon, or six-sided figure.

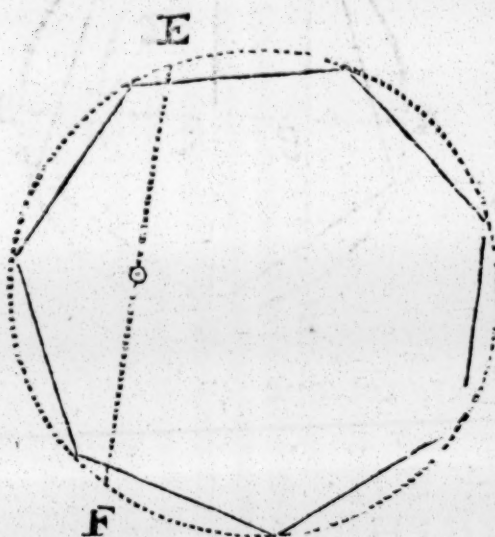
Draw an obscure circle, as you see here, and then, without altering the extent of the compasses, mark out the hexagon required round the circle; for the semidiameter of any circle is the side of the greatest hexagon that can be made within the same circle.



This

This is the way coopers use to make heads for their casks.

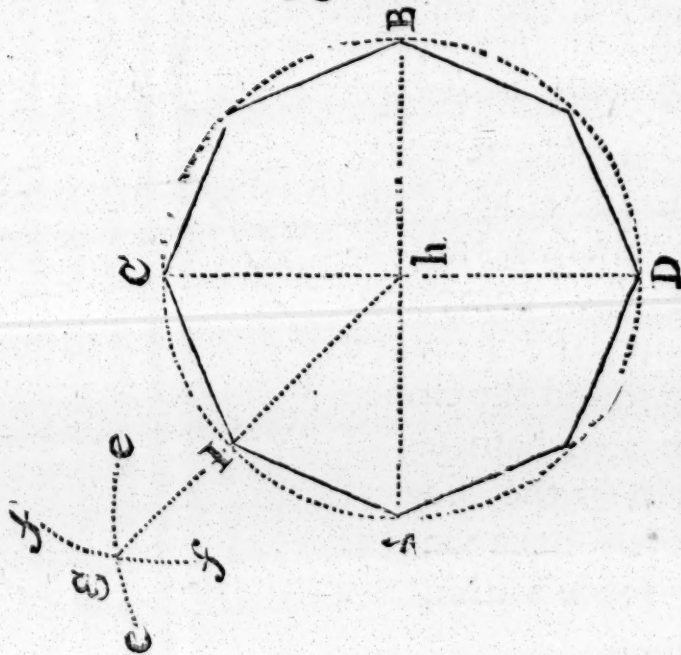
To make a heptagon, or figure of seven equal sides and angles.



You must begin and proceed, as if you were going to describe an equilateral triangle in a circle, 'till you have drawn the line EF; then taking with your compasses the half of that line, viz. from $\odot$ to E, or from $\odot$ to F, mark out round the circle your heptagon;

for the half of the line EF is the side of it.

To make an octagon, commonly called an eight-square figure.



First,

First, Make a circle.

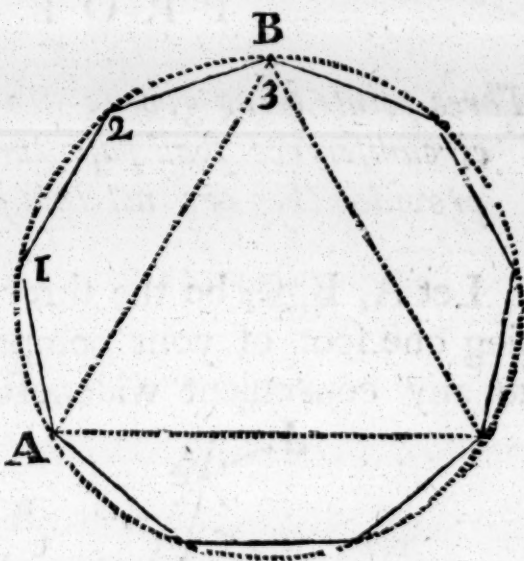
Secondly, Divide it into four equal parts by two diameters, the one perpendicular to the other, as AB and CD .

Thirdly, Set one foot of the compasses in A, and make the arch *ee*; also with the same extent set one foot in C, and make the arch *ff*; then through the intersection of the two arches draw a line to the center, viz. *g b*.

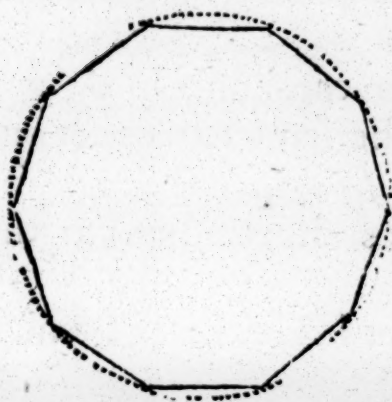
Lastly, Draw the line I C or I A, either of which is the side of an octagon.

To make a nonagon.

First, Make a circle, and an equilateral triangle in it, as you were taught at Prob. XIII. Then divide the arch A B into three equal parts, as A 1, 1 2, and B 2. Lastly, draw the lines A 1, 1 2, 2 B, &c. quite round the circle, and the nonagon will be completed.



To make a decagon.

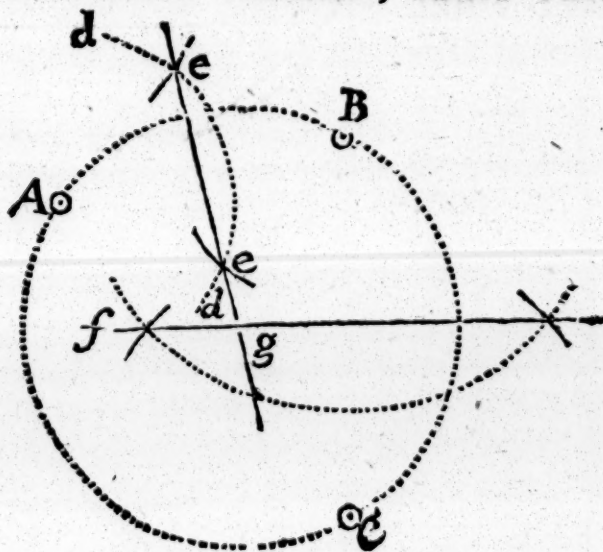


You must work altogether as you did in making a pentagon. See the pentagon above, where the distance from the center K, (see the last figure but 4) to the point at H, is the side of a decagon, or ten-sided figure.

P R O B. XIV.

Three points being given: To describe a circle, whose circumference shall pass through those given points, provided they are not in a strait line.

Let A, B, C, be the three points given; first setting one foot of your compasses in A, open them to any convenient wideness, more than half the



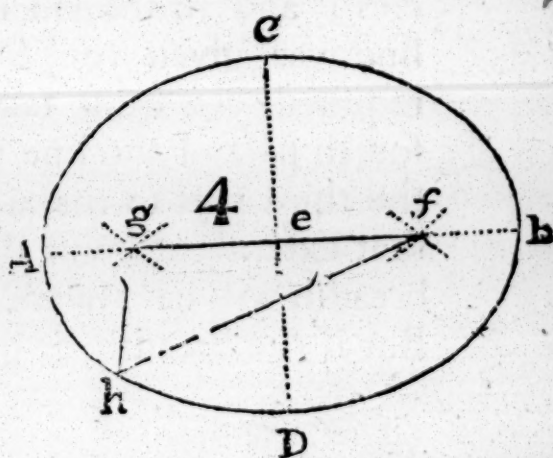
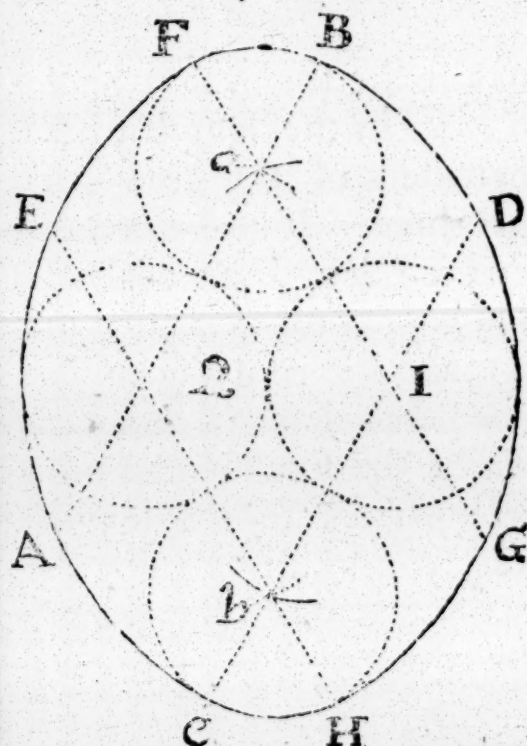
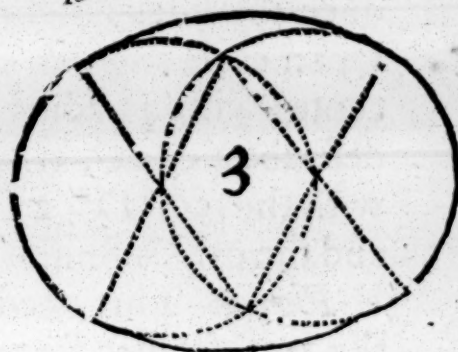
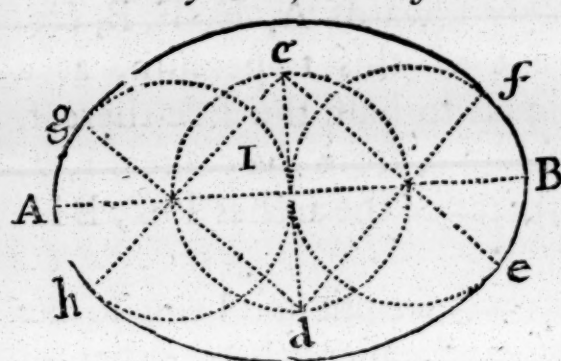
distance

distance between A and B, and describe the arch dd ; then, without altering the extent, set one point in B, and cross the first arch at e and e ; through those two intersections draw the line ee .

The very same you must do between B and C, and draw the line ff ; where those two lines intersect each other, as at g , there is the center of the circle required; therefore setting one foot of your compasses in g , extend the other to any of the points given, and describe the circle A B C. Note, the centre of a triangle is found the same way.

P R O B. XV.

To describe the carpenter's or common oval, several ways; also to describe an ellipsis.



D Fig 1.

Fig. 1. Describe a circle at pleasure, and through the center thereof draw an indefinite right line, as *A B*. On the two points where the circumference of this circle cuts the line *A B*, as centers describe circles with the same radius as before; draw *dc* perpendicular to *A B*, and passing through the center of the middle circle. From the points *C* and *d*, draw *Ce*, *C b* and *d f*, *d g*: set one foot of the compasses in *D*, and extend the other to *g*, describe the arch *g f*; with the same extent, and one foot in *C*, describe the arch *b e*; these arches together, with the circular parts *f e*, *g b*, will form the oval *A g f B c b A* required.

Fig. 2 Draw any trapezium at pleasure, and produce the sides indefinitely towards *A*, *E*, *F*, *B*, &c. Upon each angular point of this trapezium, as a center with a radius equal to half the side thereof, describe a circle; which done, from the centers 1, 2, with the radii *I F*, *2 B*, describe the arches *F C*, *B H*, and the oval is finished.

Fig. 3. This needs no description, it being so like the two former figures, and easier than either of them.

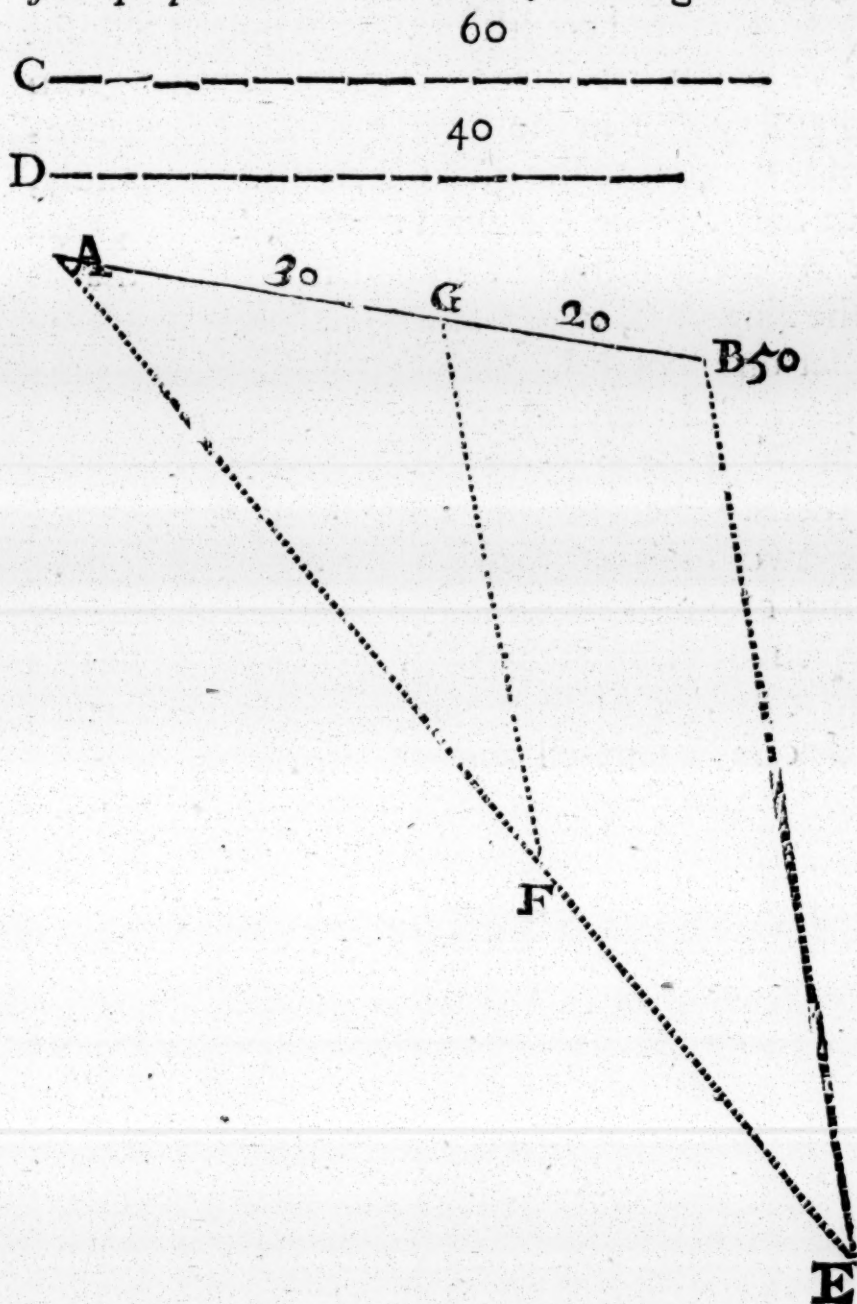
Here note, that you may make the ovals 1 and 3 of any determined length; for in the length of the first, there is four semidiameters of the small circles; and in the last but three. If therefore any line was given you, of which length an oval was required, you must take in your compasses only the fourth part of the line to make the oval *Fig. 1*, but the third part to make the oval *Fig. 3*, and with that extent you must describe the small circles: the breadth will be always proportional to the length. But if the breadth be given, you must describe the circles

circles with one fourth part thereof, to make the oval *Fig. 2.*

Fig. 4. This ellipsis is to be described by having the length and breadth both given. Let *A B* be the length, *C D* the breadth of the required ellipsis. First, Lay down the line *A B* equal to the given length, and cross it in the middle with the perpendicular *CD*, equal to the given breadth. Secondly, Take in half the line *A B* with your compasses, *viz.* *A e*, or *B e*; set one foot in *C*, and make two marks upon the line *A B*, *viz.* *f* and *g*; also with the same extent set one foot in *D*, and cross the former marks at *f* and *g*. Thirdly, at the point *f* and *g* fix two pins; or if it be a garden-plat, or the like, two strong sticks. Then putting a line about them, make fast the two ends at such an exact length, that, stretching by the two pins, the bent of the line may exactly touch *A* or *B*, or *C* or *D*, or *h*, as in this diagram it does at *h*; so moving the line still round, it will describe a true ellipsis.

P R O B. XVI.

To divide a given line into two parts, which may be in such proportion to each other, as two given lines are.



Let

Geometrical Problems.

37

Let A B be the given line to be divided in such proportion as the line C is to the line D.

First, From A draw a line at pleasure, as A E ; then taking with your compasses the line C, set it off from A towards E, which will fall at F: also take the line D, and set off from F to E.

Secondly, Draw the line E B; and from F draw F G parallel to E B, which shall intersect the given line A B in the point required, *viz.* at G; thus will A G and G B be in like proportion to each other, as C and D are.

Example by arithmetic.

The line C is 60 feet, perches, or any thing else; the line D is 40; the line A B is 50; which is required to it divide in such proportion as 60 to 40. First add the two lines C and D together, and they make 100: then say, If 100 the whole, give 60 for its greater part, what shall 50, the whole line A B, give for its greater proportional part? Multiply 50 by 60, it makes 3000; which, divided by 100, produces 30 for the greater part; which 30 taken from 50, leaves 20 for the lesser part: as therefore 60 is to 40, so is 30 to 20.

P R O B. XVII.

To find a fourth in proportional to three given lines.

Let A B C be the three given lines: it is required to find a fourth line, which may be in such proportion to C, as B is to A,

A ——— 14

B ——— 18

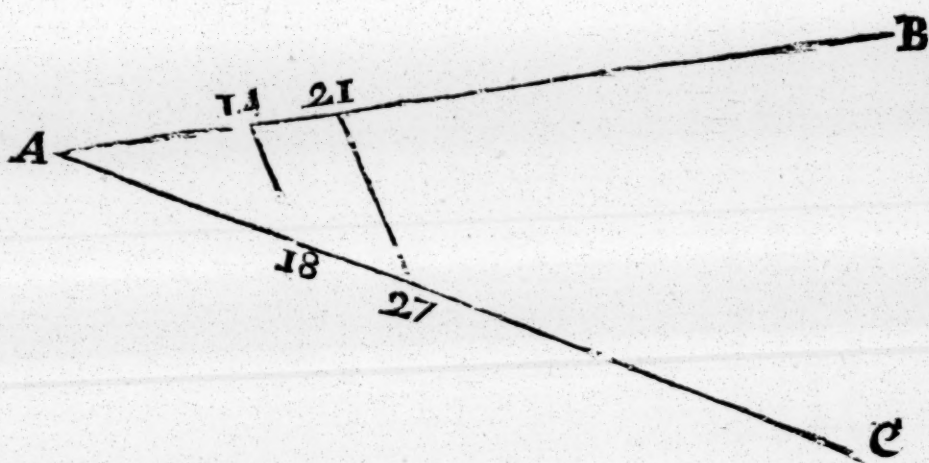
C ——— 21

D 3

which

which is no more than performing the *Rule of Three* by lines ; thus, If A 14 give B 18, then what shall C 21 give ? Answer, 27. But to perform the same geometrically, work thus :

First, make any Angle, as B A C : then take with your compasses the first line A, and set it from A to 14. Also take the second line B, and set it from A to 18 ; draw the line 14, 18. Then take



the third line C with your compasses, and set it from A to 21. From 21, draw 21, 27 parallel to 14, 18. Then will A, 27 be the length of your fourth line required.

And here for a while I shall leave these *Problems*, 'till I come to shew you how to divide any piece of land ; and to lay out any piece of a given quantity of acres into any form or figure required : and in the mean time I shall shew you in the next chapter, what is necessary to be known relating to measures of various kinds.

C H A P.

C H A P. II

Of MEASURES.

AND first of long measures; which is either inches, feet, yards, perches, chains, &c. Note, that twelve inches make one foot, three feet one yard, five yards and an half one pole or perch, four perches one chain of *Gunter's*, eighty chains one mile. But if you would bring one sort of measure into another, you must work by *Multiplication* or *Division*. As for example: suppose you would know how many inches are contained in twenty yards; first, reduce the yards into feet by multiplying them by 3, because 3 feet make one yard, the product is 60; which multiplied by 12 the number of inches in one foot, gives 720, and so many inches are contained in 20 yards length.

On the contrary if you would know how many yards there are in 720 inches you must first divide 720 by 12, the quotient is 60 feet; that again divided by 3, the quotient is 20 yards. The like you must do with any other measure, as perches, chains, &c. of which more hereafter.

Long	Link	Foot	Yard	Perch	Chain	Mile
Inches	7.92	12	36	198	792	63360
	Link	1.515	4.56	25	100	8000
		Feet	3	16.5	66	5280
			Yard	5.5	22	1760
				Perch	4	320
					Chain	80

See this table of the long measure annexed, the use whereof is very easy. If you would know how many feet in length go to make one chain, look for chain at the top, and at the left hand for feet; against which, in the common angle of meeting, is 66; so many feet are contained in one chain.

But because Mr. *Gunter's* chain is most in use among surveyors for measuring of lines, I shall chiefly insist on that measure, it being the best in use for lands.

This chain contains in length 4 poles or 66 feet, and is divided into 100 links, each link is therefore in length $7\frac{2}{100}$ inches: if you would turn any number of chains into feet, you must multiply them by 66, as 100 chains multiplied by 66, make 6600 feet; but if you have links to your chains, to be turned into feet, and parts of feet, you must set down the chains and links, as if they were one whole number, and after having multiplied that number by 66, cut off from the product the two last figures to the right hand, which will be the hundredth parts of a foot, and those on the left hand the feet required.

E X A M P L E.

Let it be required to know how many feet there are in 15 chains, 25 links.

I set down thus the *Multiplicand* 15,25

The num. of feet in one chain *Multiplicat.* 66

$$\begin{array}{r}
 15,25 \\
 \times 66 \\
 \hline
 9150 \\
 9150 \\
 \hline
 \text{Product } 1006\frac{1}{2} \text{ feet.}
 \end{array}$$

The

The *product* is $1006 \frac{50}{100}$. This is so plain, it needs no other example.

But now on the other hand, if one thousand and fix feet and an half were given you to reduce into chains and links, you must divide 1006.50 by 66, the quotient will be 1525, *viz.* 15 chains, 25 links. But for those that do not well understand *Decimal Arithmetick*, and may perhaps meet with more difficult questions of this nature, I have inserted the following table :

A TABLE, shewing how many feet, and parts of a foot; also how many perches, and parts of a perch, are contained in any number of chains and links, from one link to one hundred chains.

Links.	Feet.	Parts of a Foot.	Perches.	Parts of a Perch.	Chains.	Feet.	Perches.
1	00	. 66	0	. 04	1	60	4
2	01	. 32	0	. 08	2	132	8
3	01	. 98	0	. 12	3	198	12
4	02	. 64	0	. 16	4	264	16
5	03	. 30	0	. 20	5	330	20
6	03	. 06	0	. 24	6	396	24
7	04	. 62	0	. 28	7	462	28
8	05	. 28	0	. 32	8	528	32
9	05	. 94	0	. 36	9	594	36
10	06	. 60	0	. 40	10	660	40
20	13	. 20	0	. 80	20	1320	80
30	19	. 80	1	. 20	30	1980	120
40	26	. 40	1	. 60	40	2640	160
50	33	. 00	2	. 00	50	3300	200
60	39	. 60	2	. 40	60	3960	240
70	46	. 20	2	. 80	70	4620	280
80	52	. 80	3	. 20	80	5280	320
90	59	. 40	3	. 60	90	5940	360
100	66	. 00	4	. 00	100	6600	400

The Explanation of the Table.

If you would know how many feet are contained in 20 of Mr. Gunter's chains :

First, Under title *Chains* seek for 20; and right against it, under title *Feet*, stands 1320, the number of feet contained in twenty chains. Also under title *Perches* stands 80, the number of perches contained in twenty chains.

Again,

Again, If you would know how many feet are contained in eight links only of the chain, seek 8 under title *Links*, and right against it stands 05.28, which is five feet $\frac{28}{100}$ of a foot, something more than five feet and a quarter. Also under title *Perches*, and parts of a perch, stands 0.32; which signifies that 8 links contain 0 perch $\frac{32}{100}$ of a perch. But, to know how many feet are contained in any number of chains and links together, first seek the feet answering to the whole chains, and write them down next the first answering the links; and adding them to the other, you will have your desire. *Example:* In 15 chains, 25 links, how many feet? First, by the table I find 10 chains to contain 660 feet, which I write down thus:

And when you have added them together, you find the sum to be 1006 feet, and $\frac{50}{100}$ of a foot, that is contained in 15 chains, 25 links

<i>Chains, Feet, Parts.</i>			
	10	660	
	5	330	
<i>Links</i>	20	13	20
	5	3	30
<i>Added</i>		1006	50

In like manner, if it had been asked how many perches are contained in 15 chains, 25 links?

Of Measure.

43

In the table against 10
chains stands

5
20 *Links.*
5 *Links.*

Perch. Parts.

40
20
00 80
00 20

Answer, 60 *Perches.*

60 100

Observe, that the foregoing table is as large again as it need to be ; for you see both the columns are alike in figures, and only differenced by points. I made it so for your clearer understanding of it ; which, when you well do, you need use no more than one column ; which, if you please, you may have placed on a scale, or any other instrument. But now, to bring a less measure into a greater, requires division, and is therefore more troublesome than to bring a greater into a less, which requires only multiplication : I have therefore, for your ease, hereto annexed a large table, with which, by inspection only, or at most by a little easy addition, as in the former, you may change any number of feet into chains, links, and parts of a link (Mr. Gunter's chain is here used) also into perches, and parts of a perch.

A TABLE,

A TABLE, shewing how many Chains, Links, and Parts of a Link : also how many Perches, and Parts of a Perch, are contained in any Number of Feet, from 1 to 10000.

feet.	chain.	Link	P. or L.	Per.	P. or Per
1	0	1	515	0	000
2	0	3	030	0	121
3	0	4	545	0	181
4	0	6	000	0	242
5	0	7	575	0	303
6	0	9	090	0	303
7	0	10	606	0	424
8	0	12	121	0	484
9	0	13	636	0	545
10	0	15	151	0	606
20	0	30	303	1	212
30	0	45	454	1	818
40	0	60	606	2	424
50	0	75	757	3	030
60	0	90	909	3	030
70	1	06	060	4	424
80	1	21	212	4	848
90	1	36	363	5	454
100	1	51	515	0	060
200	3	03	030	12	121
300	4	54	545	18	181
400	6	06	060	24	242
500	7	57	575	30	303
600	9	09	090	36	363
700	10	60	606	42	424
800	12	12	121	48	484
900	13	63	636	54	545
1000	15	15	151	60	060
2000	30	30	303	121	212
3000	45	45	454	181	818
4000	60	60	606	242	424
5000	75	75	757	303	030
6000	90	90	909	363	636
7000	106	06	060	424	242
8000	121	21	212	484	848
9000	136	36	363	545	454
10000	151	51	515	606	060

This table is like the former, and needs not much explanation. However, I will give an example or two.

Admit I would know how many chains in length are contained in 500 feet. First, in the left-hand column, under title *Feet*, I look out 500, and right against it I find 7 chains, 57 links, 575 parts of 1000 of a link, or 7 chains, $57 \frac{575}{1000}$ links. So likewise under title *Perches*, I find 30 $\frac{303}{1000}$ perches. But if you would know how many feet the fraction $\frac{303}{1000}$ contains, you must seek for 303 in the column titled *Parts of a Perch*, and right against it you will find 5 feet. So I say that 500 feet is 30 perches, 5 feet.

Again, I would know how many chains and links there are in 15045 feet. First, seek for 10000, and write down the chains, links, and parts of a link contained therein. Do the like by 5000; also by 40 and 5. Lastly, adding them together, you have your desire.

<i>Feet.</i>	<i>Chain.</i>	<i>Link.</i>	<i>Prtas.</i>
10000 - -	151	51	515
5000 - -	75	75	757
40 - -	0	60	606
5 - -	0	7	575
<i>Added make</i> — —	227	95	453

Answer, 227 chains, 95 links, and 453 parts are contained in 15045 feet.

One *Example* more will be sufficient for the use of this table.

How many perches do 10573 feet make?

I

Feet.

Of Measure.

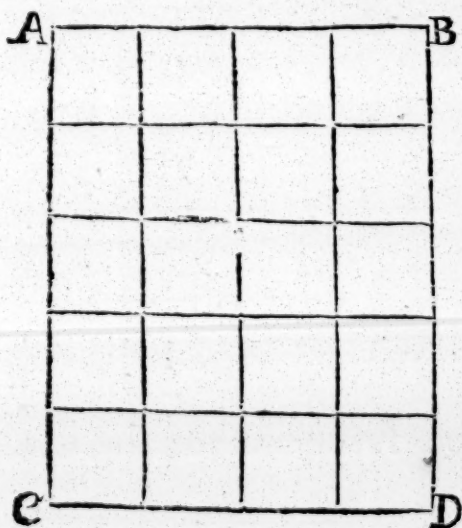
Feet.	Perches.	Parts.
10000	606	060
500	30	303
70	4	242
3	0	181
Add—	640	786

The answer is, 640 perches, and $\frac{786}{10000}$ of a perch or 13 feet. A furlong is 40 perches in length; 8 furlongs make 1 mile. Thus much for *Long Measure*: I shall now proceed to

Square Measure.

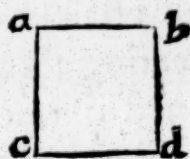
Planometry, or the measuring Superficies or Planes (as Sir *Jonas More* says) is done with the squares of such measures, as a square foot, a square perch, or chain; that is to say, by squares whose sides are a foot, a perch, or chain; and the content of any superficies is said to be found, when we know how many such squares it contains.

As for example: Suppose ABCD was a piece of land, and the length of the line A B or C D was 4 perches; also the length of the line A C or B D was 5 perches; I say, that piece of land contains 20 square perches, as you may see it here divided; every little square being a perch, having a perch in length for its side. If you lay down a square figure, whose



whose side is 1 foot, and at the end of every inch you draw lines crossing one another, as these here, you will divide that square foot into 144 little squares, or square inches.

Or thus: The line *ab* is a perch long, or 16 feet $\frac{1}{2}$, so is the line *bd*, and the other 2 lines: the whole figure *abcd* is called a square perch.



But before we go any farther, take this table following of square measure.

A TABLE OF SQUARE MEASURE.

	Inch.	Links.	Feet.	Yard.	Pace.	Perch.	Chain	Acre	Mile.
Mile	401489600	64000000	27878400	3097600	1115136	102400	6400	640	1
Perch	39204	625	272.25	30.25	10.89	1	1	1	
Pace	3600	57.381	25	2.778.	1				
Yards	1296	20.755	9	1					
Feet	144	2.295	1						
Links	62.7264	1							
Inch	2								
Chain	627264	10000	4356	484	174.24	16	1	1	
Acre	6272640	100000	43560	4840	17424	160	10	1	

This Table is like the former of long measure, and the use of it is the same.

Example : If you would know how many square feet are contained in one chain, look for feet at top, and chain on the side, and in the common angle of meeting stands 4356, so many square feet are contained in one square chain.

The common measure for land is the acre, which by statute is appointed to contain 160 square perches, and it matters not what form the acre is of so it contains just 160 square perches; as in a right angled parallelogram, 10 perches one way, and 16 another, contain an acre: so does 8 one way, and 20 another; and 4 one way, and 40 another. If then, having one side given in perches, you would know how far you must go on the perpendicular to cut off an acre: you must divide 160 (the number of square perches in an acre) by the given side, the quotient is your desire. As for example: the given side is 20 perches, divide 160 by 20, the quotient is 8: by that I know, that 20 perches one way, and 8 another, including a right angle, will be the two sides of an acre; the other two sides must be parallel to these.

And here I think it convenient to insert this necessary table, shewing the length and breadth of an acre in perches, feet, and parts of a foot: But if your given side had been in any other sort of measure; as for instance in yards, you must then have found the square yards in an acre, and that number you must have divided by the given number of yards, the quotient would have answered the question.

E X A M P L E.

E X A M P L E.

If 44 yards be given for the breadth, how many yards must there be in length to contain just one acre.

First I find, that an acre contains 4840 square yards, which I divide by 44, the quotient is 110 for the length of an acre. And thus knowing well how to take the length and breadth of an acre, you may also, by the same way, know how to lay down any number of acres together; of which more hereafter.

Reducing of one sort of square measure to another, is done as before taught in long measure by multiplication and division. And because Mr. *Gunter's* chain is chiefly used by surveyors, I shall only instance in that, and shew you how to turn any number of chains and links into acres, roods, and perches. Note, that a rood is the fourth part of an acre.

Breadth	Length of an Acre.		Breadth	Length of an Acre.	
	Perches.	Feet.		Perches.	Feet.
10	16	0	28	5	$11\frac{3}{4}$
11	14	9	29	5	$8\frac{1}{2}\frac{3}{4}$
12	13	$5\frac{1}{2}$	30	5	$5\frac{1}{2}$
13	12	$5\frac{1}{2}$	31	5	$2\frac{1}{2}$
14	11	$7\frac{1}{2}$	32	5	0
15	10	11	33	4	14
16	10	0	34	4	$1\frac{1}{3}$
17	9	$6\frac{9}{12}$	35	4	$9\frac{5}{12}$
18	8	$14\frac{8}{12}$	36	4	$7\frac{1}{2}$
19	8	$6\frac{1}{12}$	37	4	$5\frac{1}{2}$
20	8	0	38	4	$3\frac{1}{2}$
21	7	$10\frac{1}{2}$	39	4	$1\frac{1}{2}$
22	7	$4\frac{1}{2}$	40	4	0
23	6	$15\frac{1}{2}$	41	3	$14\frac{1}{2}\frac{1}{4}$
24	6	11	42	3	3
25	6	$7\frac{7}{12}$	43	3	$1\frac{1}{3}\frac{1}{2}$
26	6	$2\frac{1}{2}\frac{1}{2}$	44	3	$1\frac{1}{2}\frac{1}{2}$
27	5	15	45	3	$2\frac{1}{2}$

E

And

And first, observe that 10 square chains make 1 acre, that is to say, 1 chain in breadth, and 10 in length; or 2 in breadth, and 5 in length is an acre, as you may see by the small table here annexed.

Chains.	Chains.	Links.	Parts of a Link.
1	10	00	
2	5	00	
3	3	33	333
4	2	50	
5	2	00	
6	1	66	666
7	1	42	285
8	1	25	
9	1	11	111

And thus knowing that 10 chains make an acre, if any number of chains be given to be turned into acres, you must divide them by 10, and the quotient will be the number of acres contained in so many chains. But this division is abbreviated by only cutting off the last figure; thus if 1590 chains were given to be turned into acres, by cutting off the last figure 1590, there is left 159 acres, which is the same thing as if you had divided 1590 by 10. If any chains remain after the division by 10 is ended they may be reduced into roods and perches, thus, multiply the remaining number of square chains by 4, and cut off one figure from the right hand towards the left, the remaining figures will denote the number of square roods contained in the said chains; this done multiply the figure cut off by 40; then from the product, cut off one figure in the same manner as before, and you will have the number of perches required, expressed by the remaining figures towards the left hand.

EXAMPLE.

E X A M P L E.

In 1599 square chains, how many acres, roods, and perches?

	Acres—159 9
	4
Answer, 159 acres, 3 roods,	—
and 24 perches.	Roods—3 6
	40
	—
	Perches—24—0

On the contrary, if to any number of acres given you annex a cypher they will be turned into chains. Thus 99 acres are 990 chains, 100 acres 1000 chains, &c. the same as if you had multiplied the acres by 10. And if you would turn square chains into square links, annex four cyphers to the number of the chains; thus 990 chains will be 9900000 links, 1000 chains be 10000000 links; the very same as if you had multiplied 990 by 10000, the number of square links contained in one chain.

And now, whereas in casting up the content of a piece of land measured by Mr. *Gunter's* chain (*viz.* multiplying chains and links by chains and links) the product will be square chains and parts; you must therefore from that product cut off five figures to find the acres; which is the same as dividing the product by 100000 (the number of square links contained in one acre) then multiply the five figures cut off by 4; and from that product cut off five figures,

figures, you will have the roods. Lastly multiply by 40, and take away (as before) 5 figures, the rest are perches.

E X A M P L E.

Admit a right angled parallelogram, or long square, to be one way 5 chains, 55 links; and the other way 4 chains, 35 links: I demand the content in acres, roods, and perches?

$$\begin{array}{r}
 \text{Multiplicand} \quad 555 \\
 \text{Multiplier} \quad 435 \\
 \hline
 2775 \\
 1665 \\
 2220 \\
 \hline
 \end{array}$$

Answer, 2 Acres, }
 1 Rood }
 26 Perches }

$$\begin{array}{r}
 \text{Acres} \quad 2 | 41425 \\
 4 \\
 \hline
 \text{Roods} \quad 1 | 65700 \\
 40 \\
 \hline
 \end{array}$$

And $\frac{28}{100}$ Parts of a Perch.

$$\begin{array}{r}
 \text{Perches} \quad 26 | 28000 \\
 \hline
 \end{array}$$

Lastly, Because some rather chuse to cast up the content of land in perches, I will here briefly shew you how it may be done; which is only by dividing by 160 (the number of square perches contained in one acre) the number of perches given.

E X A M P L E.

Admit a parallelogram to be in length 55 perches, and in breadth 45 perches; these two multiplied together make 2475 square perches: to turn these into acres, divide by 160, the quotient is 15 acres, and 75 perches remain; which, to turn into roods, divide

divide by 40, the quotient is 1 rood, and 35 perches remain. So the content of this piece of land is 15 acres 1 rood, and 35 perches.

Here follows a table to convert perches into acres and roods.

Perches.	Acres.	Roods.	Perches.
40	0	1	00
50	0	1	10
60	0	1	20
70	0	1	30
80	0	2	00
90	0	2	10
100	0	2	20
200	1	1	00
300	1	3	20
400	2	2	00
500	3	0	20
600	3	3	00
700	4	1	20
800	5	0	00
900	5	2	20
1000	6	1	00
2000	12	2	00
3000	18	3	00
4000	25	0	00
5000	31	1	00
6000	37	2	00
7000	43	3	00
8000	50	0	00
9000	56	1	00
10000	62	2	00
20000	125	0	00
30000	187	2	00
40000	250	0	00
50000	312	2	00
60000	375	0	00
70000	437	2	00
80000	500	0	00
90000	562	2	00
100000	625	0	00

The Use of the TABLE.

In 2475 perches, how many acres and roods?

Perch.	Acr.	Rood.	Per.
2000	12	2	00
400	2	2	00
70	0	1	30

To which add the odd 5 perches 0 0 05

Answer 15 1 35

C H A P. V.

Of Instruments, and their Uses.

And first, of the Chain.

THERE are several sorts of chains, as Mr. Rathborne's of two perches in length; others of one perch long: some of 1000 feet in length. But that which is most in use among surveyors (as being indeed the best) is Mr. Gunter's, which is 4 pole long, and contains 100 links, each link being $7 \frac{22}{100}$ inches in length. The description of this chain, and how to reduce it into any other measure, you have at large in the foregoing chapter of measures. In this place I shall only give you some few directions for the use of it in measuring land.

Take care that they who carry the chain deviate not from a strait line; which you may do by standing at your instrument, and looking through the sights. If you see them between you and the mark observed, they are in a strait line, otherwise not. But without this trouble, they may carry the chain true enough, if he that follows the chain always causes him that goeth before to be in a direct line between himself and the place they are going to, so that as the foreman may always cover the mark from him that goes behind. If they swerve from
the

the line, they will make it longer than it really is, a strait line being the nearest distance that can be between any two places.

Be careful that they who carry the chain, mistake not a chain either over or under in their account; for if they should the error would be very considerable; as suppose you were to measure a field that you knew to be exactly square, and therefore need only measure one side of it: if the chain-carriers should mistake but one chain, and tell you the side was nine chains when it was really 10, you would make of the field but 8 acres and 16 perches, when it should be 10 acres just. And if in so small a line such a great error may arise, what may be in a greater you may easily imagine; but the usual way to prevent such mistakes, is to be provided with 10 small sticks, sharp at one end, to stick in the ground; and let him that goes before, take all the sticks in his hand at setting out, and at the end of every chain stick down one, which let him that follows take up: when the 10 sticks are used, you will be sure they have gone 10 chains: then if the line be longer let them change the sticks, and proceed as before, keeping in memory how often they change: they may either change at the end of 10 chains, then the hindmost man must give the foremost all his sticks; or, which is better at the end of 11 chains, and then the last man must give the first but nine sticks keeping one to himself. At every change count the sticks, for fear lest you have dropt one, which sometimes happens.

If you find the chain too long for your use, as for some lands it is, especially in *America*, you may

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then take the half of the chain, and measure as before, remembering still, when you put down the measure of the lines in your field-book, that you set down but the half of the chains, and the odd links; as if a line measured by the little chain be 11 chains, 25 links, you must set down five chains, 75 links; and then in plotting and casting up it will be the same as if you had measured by the whole chain.

It is usual at the end of every 10 links to have a ring, or a piece of brass fixed, for your more ready reckoning the odd links.

When you put down in your field-book the length of any line, you may set it thus, if you please, with a stop between the chains and links, as 15 chains, 15 links, 15.15; or without, as thus, 1515 links, it will be all one in the casting up.

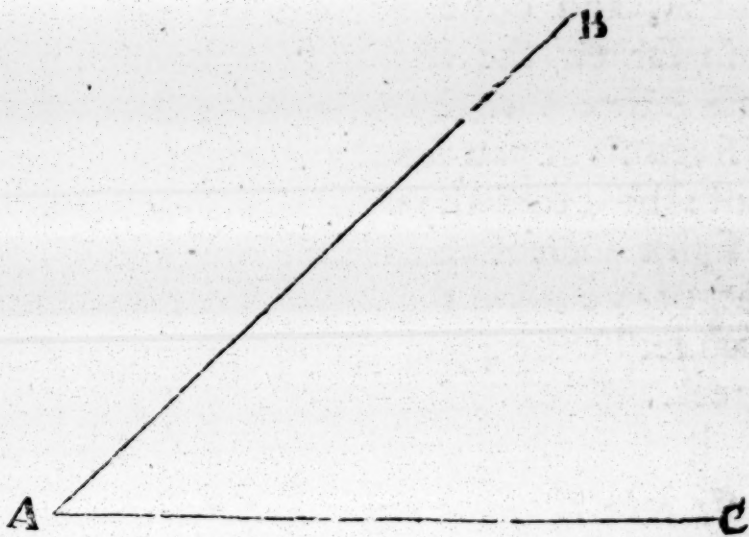
Of instruments necessary for taking of an angle in the field.

There are but two material things (towards the measuring of a piece of land) to be done in the field; the one is to measure the lines (which I have shewed you how to perform by the chain,) and the other is to take the quantity of an angle included by those lines; for which there are almost as many instruments as there are surveyors. Such among the rest as are most esteemed, are the plane table for small inclosures, the semicircle for champaign grounds, the circumferentor, the theodolite, &c. To describe these to you, with their several parts, how to put them together, take them asunder, &c. is like teaching the art of fencing by book; one hour's use of them, or but looking on them in the instrument.

instrument-maker's shop, will better describe them to you, than the reading one hundred sheets of paper concerning them. Let it suffice that the only use of them all is no more (or chiefly at most) but this, *viz.*

To take the quantity of an angle.

As suppose *AB* and *AC* are two hedges, or other fences of a field, the chain serves to mea-



sure the length of the sides *AB* or *AC* and these instruments we are speaking of, are to take the angle *A*. And first, by the

Plane Table.

Place the table (already fitted for the work, with a sheet of paper upon it) as nigh to the angle *A* as you can, the north end of the needle hanging directly over the *flower-de-luce*; then make a mark upon the sheet of paper at any convenient place for the angle *A*. and lay the edge of the index to the mark,

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mark, turning it about, 'till through the sights you view the point B, then draw the line A B by the edge of the index. Do the same for the line A C, keeping the index still upon the first mark, then will you have upon your table an angle equal to the angle in the field.

To take the quantity of the same angle by the semicircle.

Place the center of your semicircle in the angular point A, and cause marks to be set up near B and C, so far off the edges, as your instrument at A stands; then turn the instrument about 'till through the fixed sight you see the mark at B, there screw it fast: next turn the moveable index, 'till through the sights thereof you see the mark at C, then see what degree upon the limb is cut by the index; which let be the 45th, then is the angle A B C 45 degrees.

To take the same angle by the circumferentor.

Place your instrument, as before, at A, with the *flower-de-luce* towards you, direct your sights to the marks at B, and see what degree is cut by the south end of the needle, which let be the 55th; do the same to the mark at C, and let the south end of the needle there cut 100; subtract the lesser out of the greater the remainder is 45, the angle required. If the remainder had been more than 180 degrees, you must then have subtracted it out of 360, the last remainder would have been the angle desired.

Of Instruments and their Uses: 59

This last instrument depends wholly upon the needle for taking of angles, which often proves erroneous ; the needle yearly of itself varying from the true *north*, if there be no iron mines in the earth, or other accidents to draw it aside, which in mountainous lands are often found : it is therefore the best way for the surveyor, where he possibly can, to take his angles without the help of the needle, as is before shewed by the semicircle. But in all lands it cannot be done; but we must sometimes make use of the needle, and not without exceeding great trouble, as in the thick woods of *Jamaica, Carolina, &c.* It is good, therefore, to have such an instrument as a semicircle, with which an angle in the field may be taken either with or without the needle, and there is no better instrument that I know of, for the surveyor's use, yet made public; therefore, as I have before shewed you, how by the semicircle to take an angle without the help of the needle, I shall here direct you

How to take the quantity of an angle in the field by the semicircle and needle.

Screw fast the instrument, with the north end of the needle hanging directly over the *flower-de-luce* in the card; turn the index about till through the sights you see the mark at B; and note what degree the index cuts, which let B be the 40th; move again the index to the mark at C, and note the degree cut, *viz.* 85. Subtract the less from the greater, remains 45, the quantity of the angle.

Or

Or thus :

Turn the whole instrument, 'till thro' the fixed sights you see the mark at B ; then observe what degree upon the card is cut by the needle ; which, for example, suppose the 315th. Turn also the instrument, till through the same sights you espy C, and note the degree upon the card then cut by the needle, which suppose 270 ; subtract the less from the greater, (as before in the working by the circumferentor) remains 45 degrees for the angle. Note, if you turn the *Flower-de-luce* towards the mark, you must look at the north end of the needle for your degrees.

Besides the division of the card of the semicircle into 360 equal parts or degrees, it is also divided into four quadrants, each containing 90 degrees, beginning at the north and south point, and proceeding both ways till they end in 90 degrees at the east and west points ; those points are marked contrary, *viz.* East with a W, and West with an E ; because when you turn your instrument to the eastward, the end of the needle will hang upon the west side, &c.

If by this way of division of the card, you would take the aforesaid angle, direct the instrument so, (the *flower-de-luce* from you) 'till through the fixed sights, you espy the mark at B ; then see what degrees are cut by the north end of the needle, which let be N. E. 44 ; next direct the instrument to C, and the north end of the needle will cut N. E. 89 ; subtract the one from the other, and there will remain 45 degrees for the angle.

But if at the first sight the needle had hung over N. E. 55, and at the second S E 80, then take 55 from

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from 90, remain 35; take 80 from 90, remains 10; which added to 35, makes 45, the quantity of the angle: moreover if at the first sight the north end of the needle had pointed to N. W. 22, and at the second N. E. 23, these two must have been added together, and they would have made 45, the angle as before.

Note if you had turned the south-part of your instrument to the marks, then you must, have had respect to the south end of your needle.

Although I have been so long shewing you how to take an angle by the needle, yet when we come to survey land by the needle, as you shall see farther on, we need take but half the pains; for we take not the quantity of the angle included by two lines, but the quantity of the angle each line makes with the meridian; then drawing meridian lines upon paper, which represent the needle of the instrument, by the help of a protractor, which represents the instrument, we readily lay down the lines and angles in such proportions as there are in the field.

This way of dividing the card into four quarters each being 90 degrees is in my opinion, for any work the best; but there is a greater use yet to be made of it, which shall hereafter be shewed in its proper place.

Of the Field-Book.

You must always have in readiness in the field a little book, in which fairly to insert your angles and lines; which book you may divide by lines into columns, as you shall think convenient in your practice; leaving always a large column to the right hand, to put down what remarkable things you meet with in your way, as ponds, brooks, mills, trees, or the like. Thus for example, if
you

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you had taken the angle A, and found it to contain 45 degrees ; and measured the line AB, and found it to be 12 chains, 55 links, set it down in your field-book thus :

	Degr.	Min.	Chain.	Link.
A	45	00	12	55

or if at A you had only turned the fixed sights to B, and the needle had then cut 315 ; in the place of 45, you must have put down 315. If you survey by Mr. *Norwood's* way there must be four columns more for the cardinal points E. W. N. and South. You may also make two columns more, if you please for off-sets, to the right and left.

Lastly you may chuse whether you will have any lines or not, if you can write strait, and in good order, the figures directly one under another. For this I leave you chiefly to your own fancy ; for I believe there are scarce two surveyors in *England*, that have exactly the same method for their field notes.

Of the Scale.

Having by the instrument before spok enof, measured the angles and lines in the field ; the next thing to be done, is to lay down the same upon paper ; for which use the scale serves. There are several sorts of scales both large and small, according as men have occasion to use them : but all do principally consist of no more but two sorts of lines : the first is of equal parts. For the laying down chains and links ; the second a line of chords, for laying down or measuring angles. I cannot better explain the scale to you, than by shewing the figure of such a one as are commonly sold in shops, and teaching how to use it.

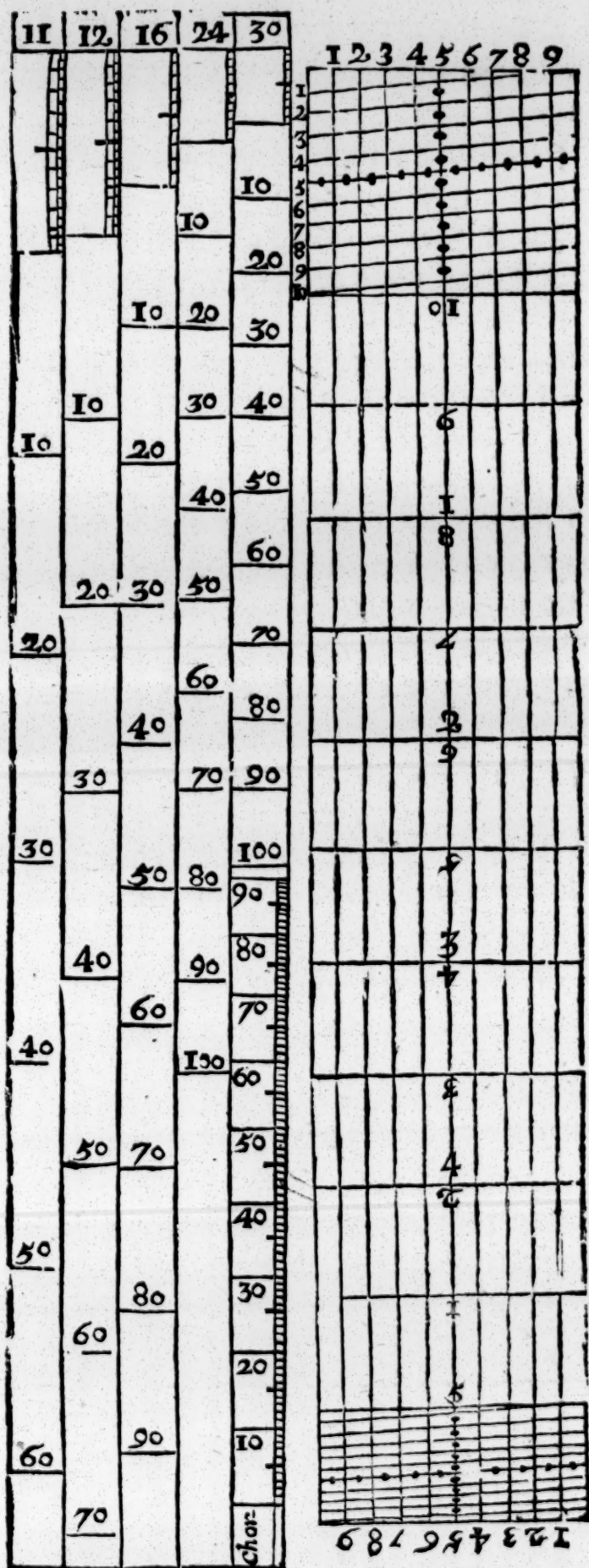
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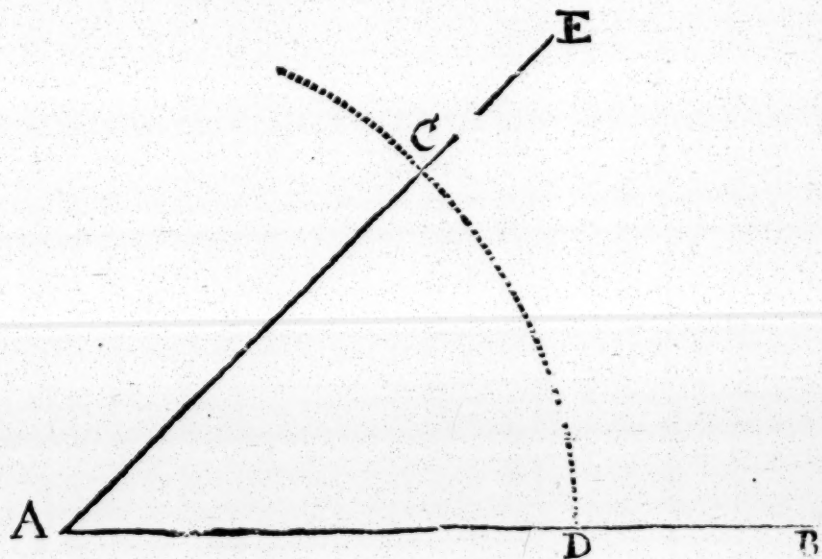
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The lines numbered at top with 11, 12, 16, &c. are lines of equal parts, containing 11, 12, or 16 equal parts to an inch, foot, yard, &c. If now by the line of 11 to an inch you would lay down 10 chains 50 link, look down the line under 11, and setting one foot of your compasses in 10, close the other till it just touch 50 links, or half a chain, in the small divisions. Then laying your ruler upon the paper, by the side thereof, with the same extent of the compasses

A———B mark the points A and B, and draw the right line A B, which will measure in length 10 chains, 50 links, by the scale of 11 to an inch. On the back-side of the scale, there is a line of 10 equal parts to an inch, but divided by a diagonal line, for the more readily taking off any required line or number to 100 parts.

To lay down an angle by the line of chords.

Let it be required to make an angle that shall contain 45 degrees.



Draw

Draw a line at pleasure, as A B : then setting one foot of your compasses at the beginning of the line of chords, see that the other fall just upon 60 degrees : with that extent set one foot in A, and describe the arch CD. Then take from your line of chords 45 degrees, and setting one foot in D, make a mark upon the arch at C, through which draw the line A E : so shall the angle E A B be 45 degrees. If by the line of chords you would erect a line perpendicular to a given one, it is no more than to make an angle that shall contain 90 degrees.

The reason why you are to take 60 from the line of chords to make your arch by, is, because the chord of 60 degrees is the semi-diameter of a circle, whose circumference is divided into 360 equal parts.

To make a regular Polygon, or a figure of 5, 6, 7, 8, or more, sides, by the line of chords.

Divide 360, the number of degrees contained in a circle by the number of sides you would have your figure to contain ; the quotient taken from the line of chords shall be one side of such a figure.

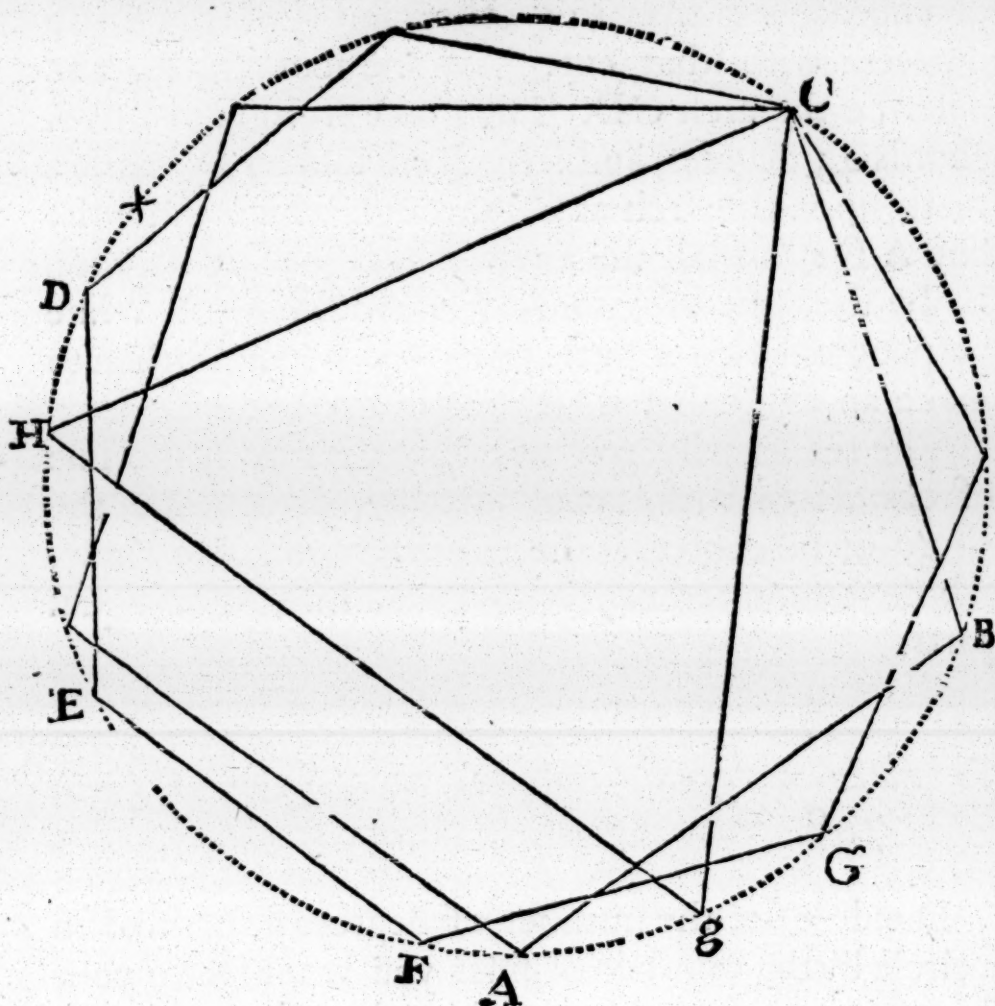
E X A M P L E.

For to make a pentagon, or a figure of five sides : divide 360 by 5, the quotient is 72, one side of a pentagon.

Take 60 degrees from your line of chords, and describe an obscure circle ; which done take 72 from
F your

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your line of chords, and beginning at any part of the circle, set off that extent round the circle, as from



B to C, and so round 'ill you come to A again. Then having drawn lines between those marks, the pentagon is compleated. The like of any other polygon, be the number of sides what they will.

Example. For the side of a heptagon: divide 360 by 7, the quotient will be 51 degr. 25 min. which if you take from the line of chords, and set off round the circle, you will form a heptagon, DE, EF, FG, &c. being the sides thereof.

To

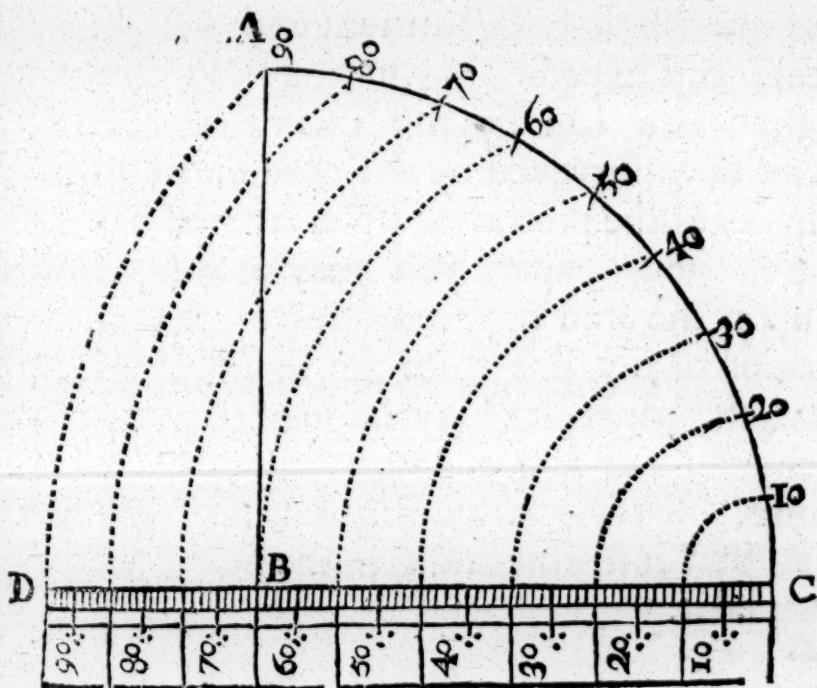
To inscribe an equilateral triangle in a circle by the line of chords.

First, take the whole length of your line of chords, or the chord of 90 degrees, with your compasses; this distance set off from C to *. Then take 30 degrees from the line of chords, and set that from * to H. Draw the line CH, which will be one side of the greatest triangle that can be inscribed in that circle.

Or you may make it by setting off twice the semidiameter of the circle; for 60 and 60 is 120, equal to 90 and 30.

To make a line of chords.

First, Make a quadrant, or the fourth part of a



F 2

circle,

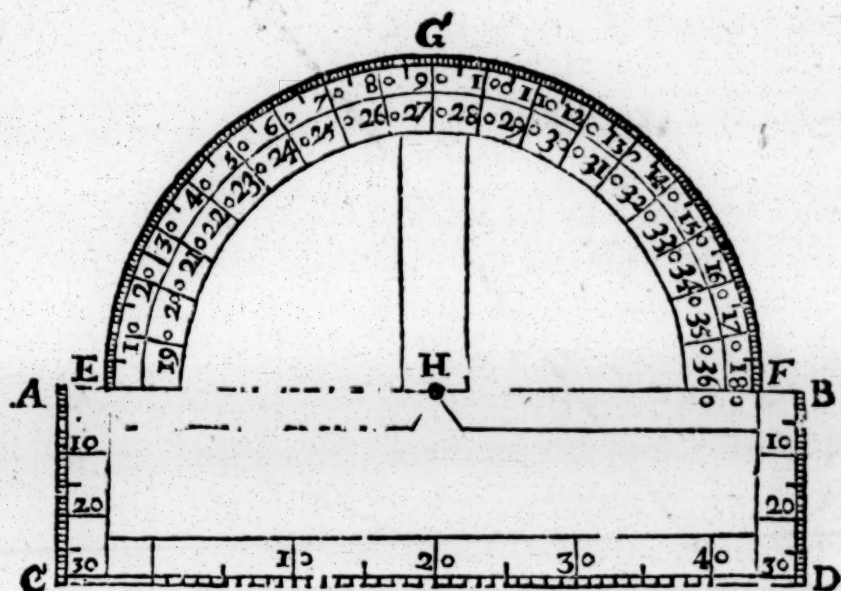
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circle, as ABC ; divide the arch thereof, viz AC , into 90 equal parts ; which you may do by dividing it first into three equal parts, and every of those divisions into three equal parts more, and every of the last divisions into ten equal parts.

Secondly, continue the semi-diameter BC to any convenient length, as to D . Then setting one foot of your compasses in C , let the other fall on 90, and describe the arch 90, 90. So likewise 80, 80 ; 70, 70, &c then will CD be the line of chords, and these arches cutting it into unequal parts, constitute the true divisions thereof, as you may see by the figure : you may, if you please, draw lines parallel to DC , as I have done here for the better distinguishing every tenth and fifth figure.

Of the Protractor.

The protractor is an instrument with which, with more ease and expedition you may lay down an angle, than you can by the line of chords : also when you have surveyed by the needle, by placing the diameter of the protractor upon a meridian line made upon your paper, you may readily with a needle upon the arch of the protractor, set off the true situation of any line from the meridian without scratching the paper, as may happen if you use the line of chords. It is graduated together like the brass limb of a semicircle, performing the same upon paper, as that instrument did in the field ; see here the figure of it.



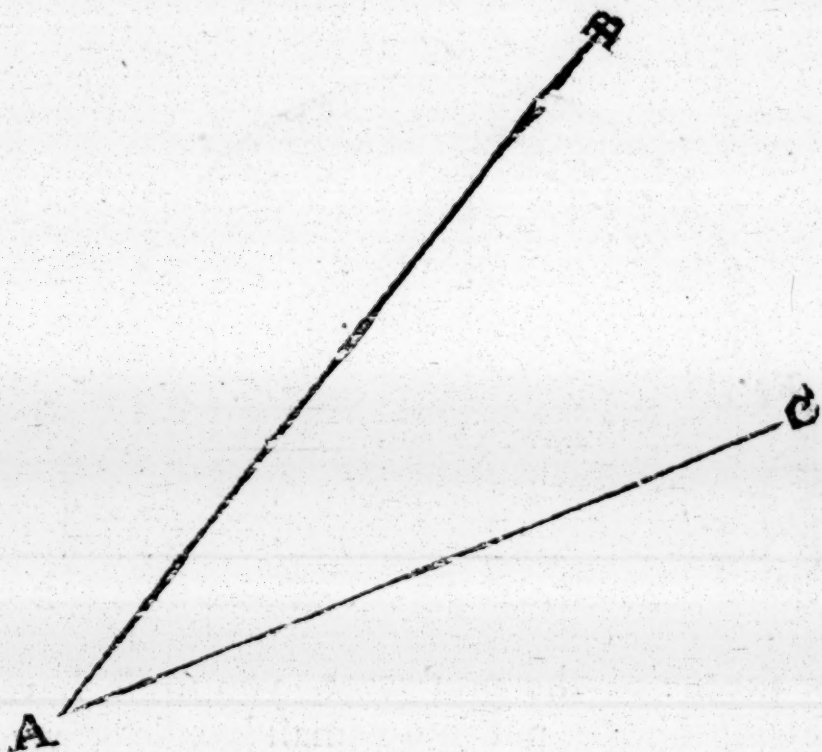
For the use of the protractor, you must have a fine sewing needle, put into a small handle of wood, or ivory, or the like, which is to put through the centre of the protractor, to any point assigned upon the paper, that the protractor may turn round upon it.

To lay down an angle with the protractor.

If it were required by the protractor to lay down an angle of 30 degrees, draw the line A B, then take the protractor, and putting a needle through the center point thereof, place the needle in A, so that the center of the protractor may lie just upon the end of the line at A, move the protractor about till you find the diameter thereof lie upon the line A B; then at 30 degrees upon the arch,

F 3

with



with your protracting needle make a mark upon the paper as at C; draw the line C A, which shall make an angle, as BAC, of 30 degrees.

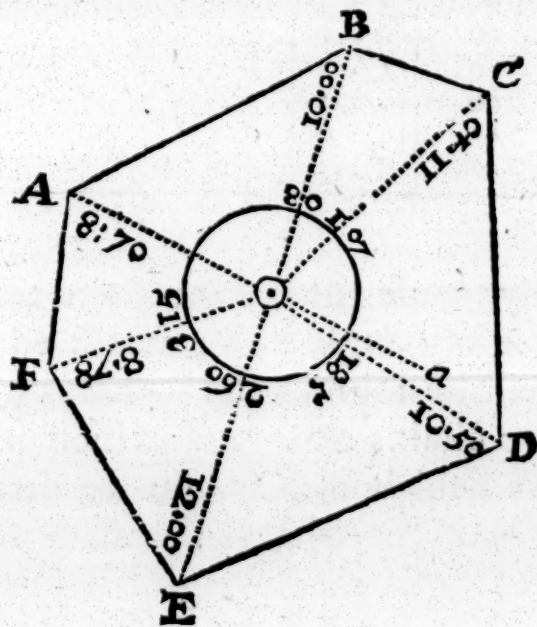
If you survey according to Mr. *Norwood's* method before spoken of, it will be necessary to have the arch of your protractor divided accordingly, *viz.* into two quadrants, or twice 90 degrees.

I need say no more of a protractor, any ingenious man may easily find the several uses thereof; it being, as it were, but only an epitome of instruments.

C H A P. VI.

To take a plot of a field at one station in any place thereof from whence you can see all the angles by the semicircle.

ADmit ABCDEF to represent a field, of which you are to take the plot: First, set your semicircle upon the staff at any convenient place thereof, as at O, and cause marks to be set up in every angle: direct your instrument, the *flower-de-luce* being from you, to any one angle: as for example to A; and espying the mark at A through the fixed sights, screw fast the instrument; then turn



F 4

the

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the moveable index about (the semi-circle remaining immoveable) 'till through the sights thereof you espy the mark at B. See what degrees on the brass limb are cut by the index, which suppose 80; write that down in your field book; so turn the index round to every one of the other angles, putting down in your field-book what degrees the index points to. As for example at C 107 degrees, at D 185: But at D, the end of the index will go off the brass limb, and the other end will come on; you must therefore look for what degrees the index cuts in the innermost circle of the limb at the points E and F; suppose 260 and 315 degrees respectively.

These observations you must note down in your field book thus:

Angles	Degrees	Minutes	Chains	Links
○ A	00	00	8	70
○ B	080	00	10	00
○ C	107	00	11	40
○ D	185	00	10	50
○ E	260	00	12	00
○ F	315	00	8	78

Secondly, cause the distance between your instrument and every angle to be measured: thus, from ○ to A will be found to be 8 chains 70 links; from ○ to B, 10 chains 00. All which set down in order in your field-book, as you see done above; and then have you got what is necessary to be known in that field towards measuring of it. Your next work is to protract or lay it down upon paper.

Divers Ways to take the Plots of Fields. 73

To protract the former observations taken.

First, draw a line at pleasure, as Aa ; then take from your scale with your compasses, the first distance measured, *viz.* from $\odot$ to A , 8 chains, 70 links; and setting one foot in any convenient place of the line, which may represent the place where the instrument stood, with the other make a mark upon the line as at A , so shall A be the first angle, and $\odot$ the place where the instrument stood.

Secondly, take a protractor, and having laid the center hereof exactly upon $\odot$, and the diameter or meridian upon the line Aa , the semicircle of the protractor lying upwards; there hold it fast, and with your protracting pen make a mark upon the paper against 80 deg. 107 deg. &c. as you find them in the field-book. Then for those degrees that exceed 180, you must turn the protractor downward, keeping still the center upon $\odot$, and placing again the diameter upon aA . Mark out by the innermost circle of divisions the rest of your observations 185, 260, 315. Then applying a scale to $\odot$ and every one of the marks, draw the dotted lines $\odot B$, $\odot C$, $\odot D$, $\odot E$, $\odot F$.

Thirdly, Take with your compasses the length of the line $\odot B$, which you find by the field-book to be 10 chains, which set off from $\odot$ to B . The like to do for $\odot C$, $\odot D$, and the rest.

Lastly, Draw the lines AB , BC , CD , &c. which will inclose a figure exactly proportionable to the field before surveyed.

To

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To take the plot of the same field at one station by the p'ane table.

Place your table with a sheet of paper upon it at $\odot$, and making a mark upon the paker, that shall signify where the instrument stands, lay your index to the mark, turning it about 'till you see through the sights the mark at A; there holding it fast, draw the line A $\odot$. Turn the index to B, keeping still upon the first mark at $\odot$; and when you see through the sights the mark at B, draw the line B $\odot$. Do the same by all the rest of the angles, and having measured the distance between the instrument and each angle, set it off with your scale and compasses from $\odot$ to A, from $\odot$ to B, &c. making marks where, upon the several lines, the distances fall.

Lastly, Between those marks draw lines, as A B, B C, C D, &c. and then have you the true plot of the field ready protracted to your hand. This instrument is so plain and easy to be understood, I shall give no more examples of the use of it. The greatest inconveniency that attends it is, that when any rain, or even dew falls, the paper will be wet, and the instrument useless.

To take the plot of the same field at one station by the semicircle, either with the help of the needle and limb both together, or by the help of the needle alone.

In the beginning of this chapter, I shewed you how to take the plot of a field at one station, by the

Divers Ways to take the Plots of Fields. 75

the semicircle, without respect to the needle, which is the best way: but that I may not leave you ignorant of any thing belonging to your instrument, I shall here shew how to perform the same with the help of the needle two ways; and first with the needle and limb together.

Fix the instrument as before, in $\odot$, making the north point of the needle hang directly over the *Flower-de-luce* of the card; there screw fast the instrument. Then turn the index to all the angles, noting down what degrees are cut thereby at every angle, as at A suppose 25, at B 105, at C 132; and so of the rest round the field. And when you have measured the distances, and are come to protraction, you must first draw a line cross your paper, calling it a north and south line, which represents the meridian line of the instrument. Then applying the protractor to that line, mark round the degrees as they were observed, viz. 25, 105, 132, &c. and having set off the distances, and drawn the outward lines agreeable to what you were taught at the beginning of the chapter, you will find the figure to be the same as there described.

Now to perform this by the needle only is in a manner the same as the former: for instead of turning the index about the limb, and observing what degrees are cut thereby, here you must turn the whole instrument about, and note at every angle what degrees upon the card the needle hangs over; which set down and protract as before. But here observe, some cards are numbered from the north eastwards 10, 20, 30, &c. to 360 deg. others from the north westward, which indeed are best for this use,

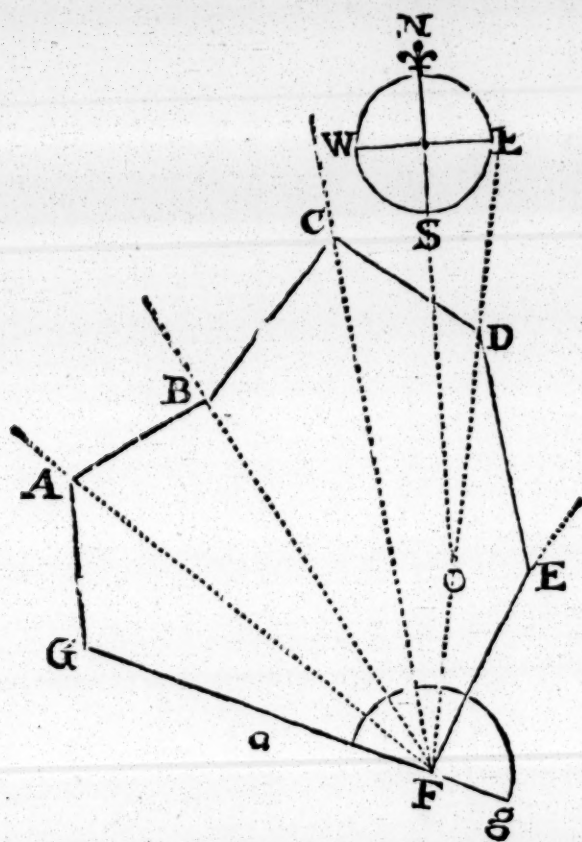
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use, protractors being made accordingly : for when you turn your instrument to the eastward, the needle will hang over the westward division, on the contrary.

As for the use of the division of the card into four quadrants, I shall speak largely of by and by; therefore for the present beg your patience.

To take the Plot of a field, at one station, by the semicircle placed in any angle thereof, from whence the other angles can be seen.

Let GABCDEF be the field, and F the angle



at which you would take your observations. Having placed your semicircle at F, turn it about the north

Divers Ways to take the Plots of Fields. 77

north point of the card from you, 'till through the fixed sights, (*Note*, that I call them the fixed sights which on are the fixed diameter) you espy the mark at G. Then screw fast the instrument; which done, move the index, till, through the sights thereof, you see the mark at A, and the degrees on the limb there cut by it will be 20. Move again the index to the mark at B, where you will find it to cut 40 deg. Do the same at C, and it cuts 60 deg. Likewise at D 77, and at E 100 deg. Note down all these angles in your field-book: next measure all the lines, as from F to G 14 chains, 60 links; from F to A 18 chains, 20 links; from F to B 16 chains, 80 links; from F to C 21 chains, 20 links; from F to D 16 chains, 95 links; from F to E 8 chains 50 links; and then will your field-book stand thus:

Angles.	Degrees.	Minutes.	Chains.	Links.
			FG 14	60
GFA	20	00	FA 18	20
GF B	40	00	FB 16	80
GF C	60	00	FC 21	20
GFD	77	00	FD 16	95
GFE	110	00	FE 8	50

To protract the former observations.

Draw a line at adventure, as Gg, upon any convenient place; on which lay the center of your protractor, as at F, keeping the diameter thereof right upon the line Gg. Then make marks round the protractor at every angle, as you find them in the field-book, viz. against 20, 40, 60, 77, and 100; which

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which done, take away the protractor, and applying the scale or ruler to F, and each of the marks, draw the lines F G, F A, F B, F C, F D, and F E. Then setting off upon these lines the true distances as you find them in the field-book; thus for the first line F G, 14 chains, 60 links; for the second F A, 18 chains, 20 links, &c. make marks where the end of these distances fall, which let be at G, A, B, C, &c.

Lastly, Between these marks, drawing the lines G A, A B, B C, C D, D E, E F, F G, you will have compleated the work.

When you survey thus without the help of the needle, you must remember before you come out of the field to make the meridian line, that you may be able to make a compass showing the true situation of the land, in respect of the four quarters of the heavens; I mean *East, West, North, and South*: which you may do thus:

The instrument still standing at F, turn it about 'till the needle lies directly over the *flower-de-luce* of the card; there screw it fast. Then turn the moveable *index*, 'till, through the sights, you espy any one angle.

As for example: Let it be D: note then what degrees upon the limb are cut by the index, which let be 10 deg. Mark this down in your field-book, and when you have protracted as before directed, lay the center of your protractor upon any place of the line F D, as at $\odot$, turning the protractor about 'till to 10 deg. lie directly upon the line F D. Then against the end of the diameter of the protractor, make a mark as at N, and draw the line N $\odot$, which is a meridian, or north or south line, by which you may make a compass.

Note,

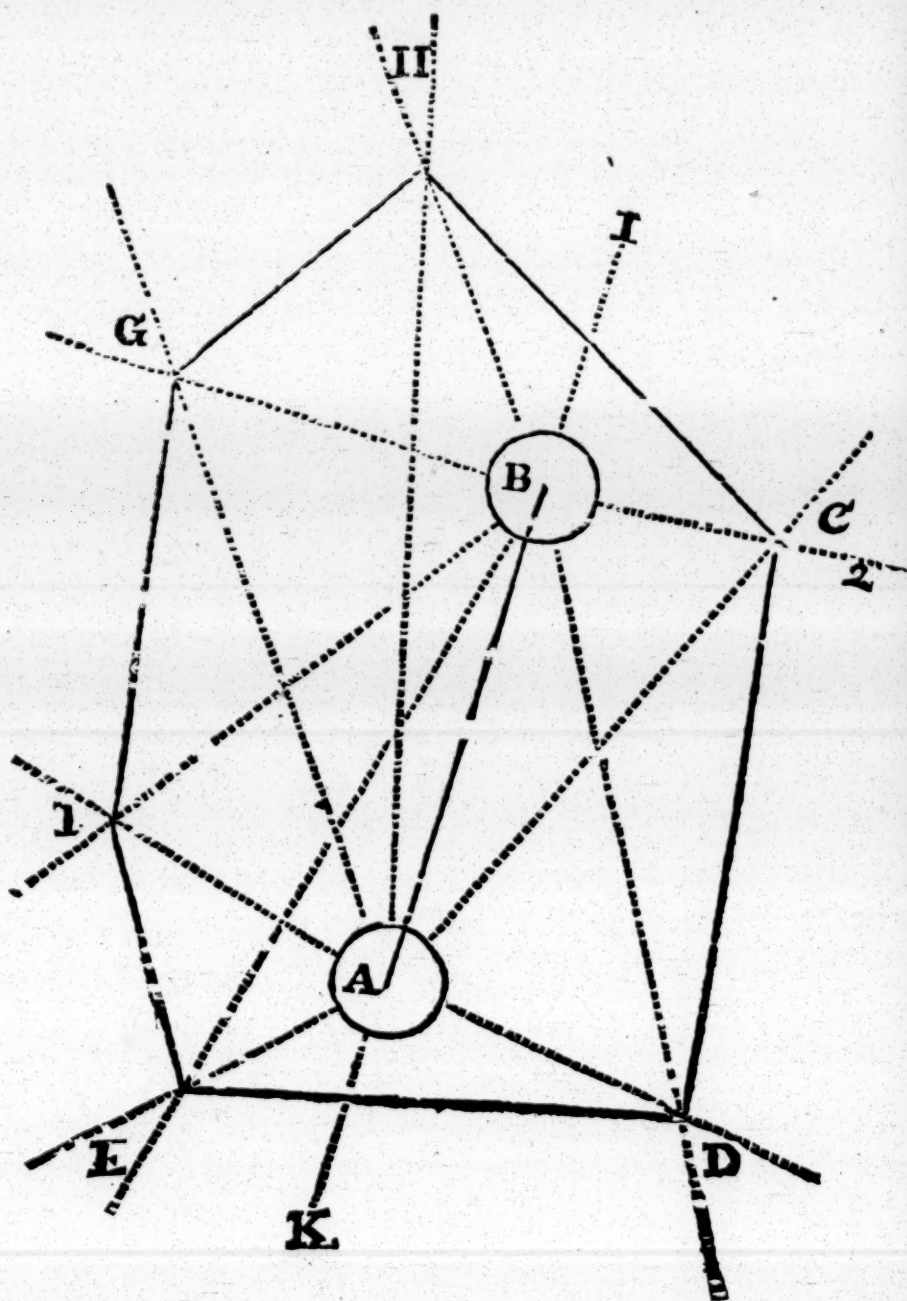
Divers Ways to take the Plots of Fields. 79

Note, You may take the plot of a field at one station, by standing in any side thereof, as well as in an angle: for if you had set your instrument in *a*, the work would have been nearly the same.

To take the plot of a field at two stations, provided from either station you can see every angle; by measuring only the stationary distance, and observed angles.

Let CDEFGHC be supposed a field to be measured at two stations: first, when you come into the field, make choice of two places for your stations, as far asunder as the field will conveniently admit of; also take care that if the stationary distance were continued, it would not touch any angle of the field; then setting the semicircle at A, the first station, turn it about, the north point from you, 'till, through the fixed sights, you espy the mark at your second station, which admit to be at B, there screw fast the instrument; then turn the moveable index to every several angle round the whole field, and see what degrees are cut thereby

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by at every angle, which note down in your field-book, as followeth :

Angles,

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Angles.	Degr.	Min.	
BAC	24	30	
BAD	97	00	
E	225	00	First station.
F	283	30	
G	325	00	
H	346	00	

Secondly, Measure the distance between the two stations, which let be 20 chains, and set it down in the field-book thus :

Stationary distance 20 chains, 00 links.

Thirdly, Placing the instrument at B, the second station, look backwards through the fixed sights to the first station at A, (I mean by looking backward, that the south part of the instrument be towards A) and having espied the mark at A, make fast the instrument, and moving the index as you did at the first station to each angle, see what degrees are cut by the index, and note them down as followeth ; and then have you done, unless you will take a meridian line before you move the instrument ; which you were taught to do in the last example.

Angles.	Degr.	Min.	
IBC	84	00	
IBD	149	00	
E	194	00	The second station.
F	215	00	
G	270	00	
H	322	00	

G

How

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How to protract or lay down upon paper these following observations.

First, Draw a line cross your paper at pleasure, as the line I K ; then take off from the scale the stationary distance 20 chains, and set it upon that line, as from A to B, so shall A represent the first station, B the second.

Secondly, Apply the center of your protractor to the point A, and the diameter lying strait upon the line B K ; mark out round it the angles, as you find them in the field-book, and through those marks from A draw lines of a convenient length.

Thirdly, Move your protractor to the second station B, and there mark out your angles, and draw lines, as before, at the first station.

Lastly, The places where the lines of the first station, and the lines of the second intersect each other, are the angles of the field. As for example :

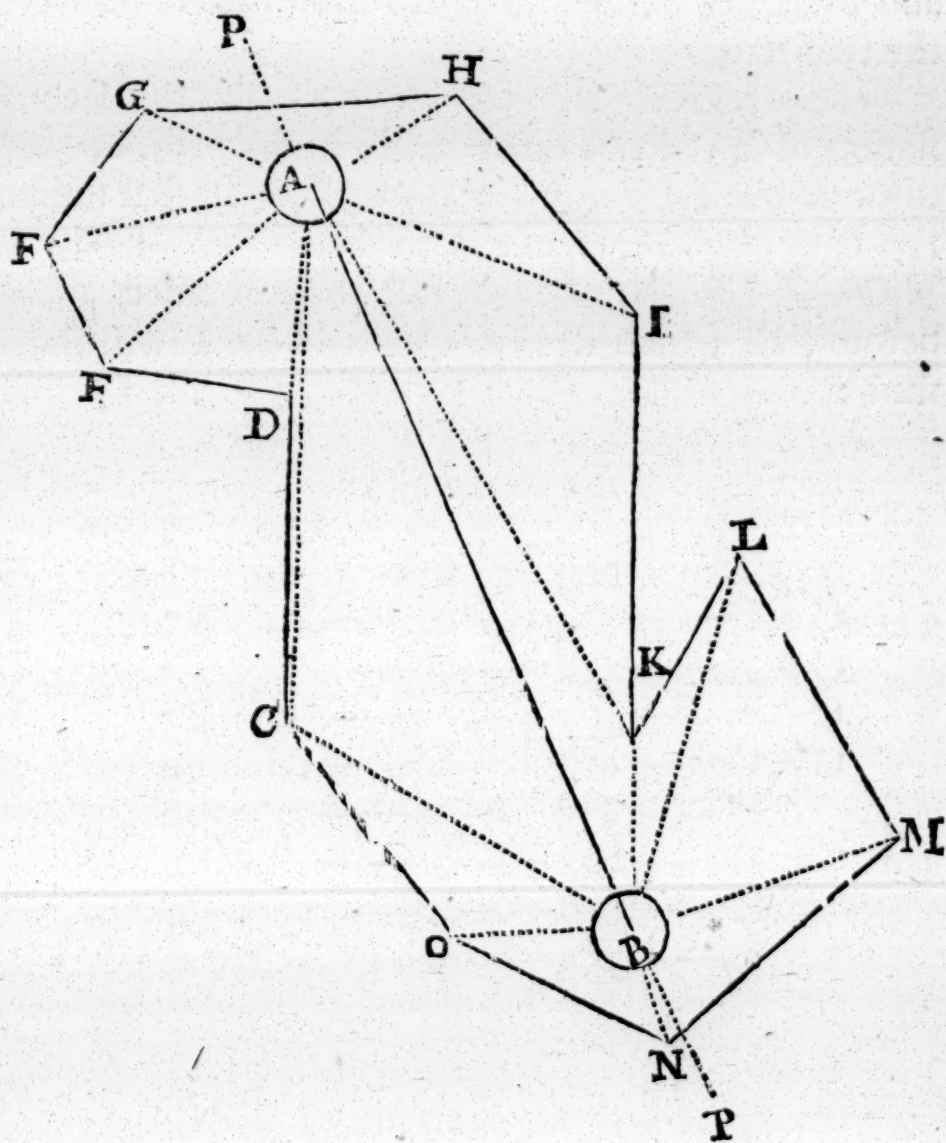
At the first station the angle C was 24 degrees 30 minutes, through those degrees I draw the line A C. At the second station C was 84 degrees; accordingly from the second station I draw the line B 2 : Now, I say, where these two lines cut each other, as they do at C, there is one angle of the field. So likewise of D, E, and the rest of the angles ; if therefore between these intersections you draw strait lines, as C D, D E, E F, &c. you will have a true figure of the field.

This may as well be done by taking two angles for your stations, and measuring the line between them,

Divers Ways to take the Plots of Fields. 83

them, as C and D ; from whence you might as well have seen all the angles, and consequently as well have performed the work.

To take the plot of a field at two stations, when the field is so irregular, that from one station you cannot see all the angles.



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Let C D E F G H I K L M N O C be a field, in which from no one place thereof all the angles may be seen ; chuse therefore two places for your stations, as A and B ; and setting the semicircle in A, direct the diameter to the second station B ; there making the instrument fast, with the index take all the angles at that end of the field, as C D E F G H I K, and measure the distance between your instrument and each angle ; measure also the distance between the two stations A and B.

Secondly, Remove your instrument to the second station at B ; and having made it fast, so as that through the back-sights you may see the first station A, take the angle at that end of the field, as N O C K L M N, and measure their distances also as before ; all which done, your field-book will stand thus :

First station.

Angles.	Degr.	Min.	Chains.	Links.
C A D—	25—	00—	20 :	75
C A E—	31—	00—	8 :	10
C A F—	67—	00—	9 :	85
C A G—	101—	00—	10 :	80
H—	137—	00—	7 :	00
I—	262—	00—	6 :	70
K—	316—	00—	13 :	70
C—	354—	00—	24 :	50

The distance between two stations, 31 chains, 60 links.

Second

Second station.

Angles.	Degr.	Min.	Chains.	Links.
P B N .	3	30	= 4	20
P B O .	111	00	= 7	00
P B C .	145	00	= 15	60
K .	205	00	= 7	48
L .	220	00	= 15	00
M .	274	00	= 11	20

To lay this down upon paper, draw at pleasure the line P B A P ; then taking in with the compasses the distance between the two stations, *viz.* 31 chains, 60 links ; set it upon the line, making marks with the compasses, at A and B ; A being the first station, B the second, lay the protractor to A, with the north end of the diameter towards B, and mark out the several angles observed at your first station, drawing lines, and setting off the distances, as you were taught in the beginning of this Chapter, *Fig. 1.*

Do the same at B, the second station ; and when you have traced out all the distances between those marks, draw the bound-lines.

I am rather more brief in this, because it is the same as was taught concerning *Fig. 1* ; for if you conceive a line to be drawn from C to K, then would there be two distinct fields to be measured at one station in each.

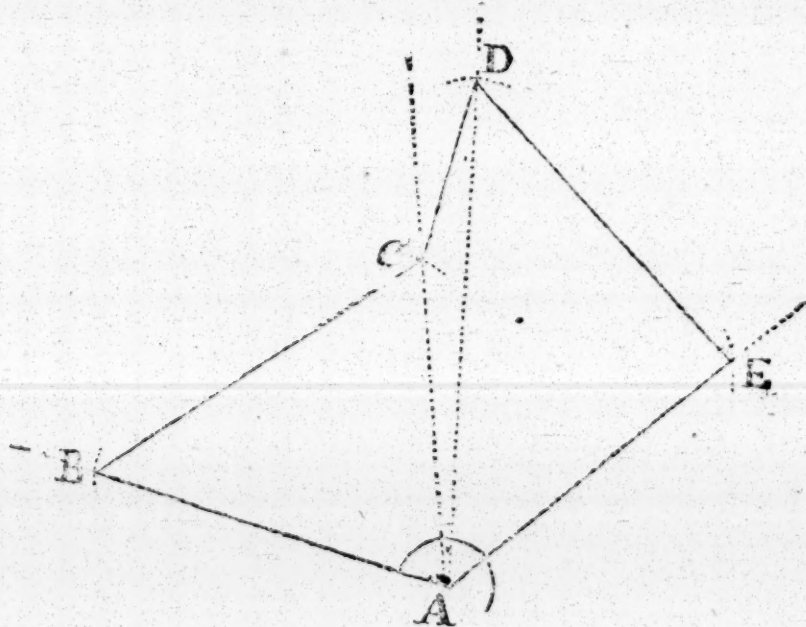
If a field be very irregular, you may, after the same manner make three, four, or five stations, if you please ; but I think it better to go round such a field, and measure the bounding lines thereof : which I shall shew you how to do farther on.

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Note, In the foregoing figure you might as well have had your stations in two convenient angles, as D and K, and have wrought as you were taught concerning *Fig. 2.* the work would have been the same.

To take the plot of a field at one station in an angle (provided from that angle you can see all the other angles) by measuring round about the said field.

A B C D E A is a field, and A the angle appointed for the station; place your semicircle in A, and direct the diameter thereof, 'till, through the fixed sights, you see the mark at B; then screw it fast, and turn the index to C, observing what degrees are there cut upon the limb; which suppose 68 degrees: turn it further, 'till you espy D, and note down the degrees there cut, *viz.* 76; do the like at E, and



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do the like at E, and the index will cut 124 degrees: this done measure round the field, noting down the length of the side lines between angle and angle, as from A to B, 14 chains 00 links; from B to C, 15 chains, 00 links; from C to D, 7 chains, 00 links; from D to E, 14 chains, 40 links: and from E to A, 14 chains, 5 links.

Then will your field-book be as hereunder.

Angles.	Degr.	Min.	Links.	Chains.	Links.
B A C—	68	. 00	A B—	14	. 00
B A D—	76	. 00	B C—	15	. 00
B A E—	124	. 00	CD—	7	. 00
			DE—	14	. 40
			E A—	14	. 5

To protract the figure, draw the right line A B at pleasure; and applying the center of the protractor to A, (the diameter lying upon the line A B, and the semicircle of it upwards) mark off the angles as 68 : 76 : and 124 : thro' these marks draw the lines A C, A D, A E, of sufficient length; then take in your compasses, from off the scale, the length of the line A B, viz. 14 chains, and setting one foot of the compasses in A, with the other cross the line, as at B; also for B C take off 15 chains, and setting one foot in B, with the other cross the line A C, which determines the point C; for the line C D, take off 7 chains, and setting one foot in C, cross the line A D, at D; then for D E, take 14 chains,

G 4

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chains, 40 links, and setting one foot of the compasses in D E, with the other cross the line A E, at E. Lastly, take E A 14 chains 5 links in your compasses, and set one point in E; then if the other will fall exactly upon A, you have done the work true; if not, you have erred: between the points of intersection draw strait lines, which shall be the bounds of the field, viz. AB, B C, C D, D E, E A.

To take the plot of the foregoing field, by measuring one line only, and taking observations at every angle.

Begin as you have been just before taught, 'till you have taken the angles BAC, BAD, and BAE, viz. 68, 76, and 124 degrees; then leaving a good mark at A, which may be seen all round the field, go to B, measuring as you go the distance from A to B, which is the only line you need measure; and planting your semicircle at B, direct the south part thereof toward A, until through the back fixed sights you see the mark at A; there making it fast, turn the index about 'till you espy C, and note down the degrees there cut, which suppose 129; move your instrument to C, and still keeping the south part of the diameter to A, turn the index to D, where it will cut 20 degrees: then remove to D, and espying A through the back sights, turn the index to E, where it will cut 135 degrees. Note all this down in your field-book.

Angles

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*Angles taken at the
first station.*

BAC— 68 }
BAD— 76 } Degrees.
BAE—124 }

Line AB: 14 chains.

*External angles round
the field.*

B . 129 }
C . 20 } Degrees.
D . 235 }

To protract this, you must work as you were taught concerning the foregoing figure, until you have drawn the lines, A C, A D, A E, and set of the line A B, 14 chains; then laying the center of your protractor to B, and the south end of the diameter (or that marked with 180 degrees) towards A, make a mark against 129 degrees, and through that mark from B, draw the line B C, 'till it intersect the line A C, which it will do at C. Lay also the center of the protractor upon C, and the diameter thereof along A C; and against 20 degrees make a mark, through which from C draw the line C D, 'till it intersect the line A D, which it will do at D. Lastly, place your protractor at D, with the diameter thereof lying upon the line D A, and make a mark against 135 degrees; through this mark draw the line D E, to intersect the line A E, as at E, draw the line E A, and you have done.

This may be otherwise performed, thus: After you have, (standing at A) taken the several angles, and measured the distance A B, you may only take the quantity of the bounding angles, without respect to A; as the internal angle at B 51 degrees, at C (an outward angle, which in your field-book you should distinguish with a mark $\neg$) 118, and so of the rest. And when you come to plot, having found

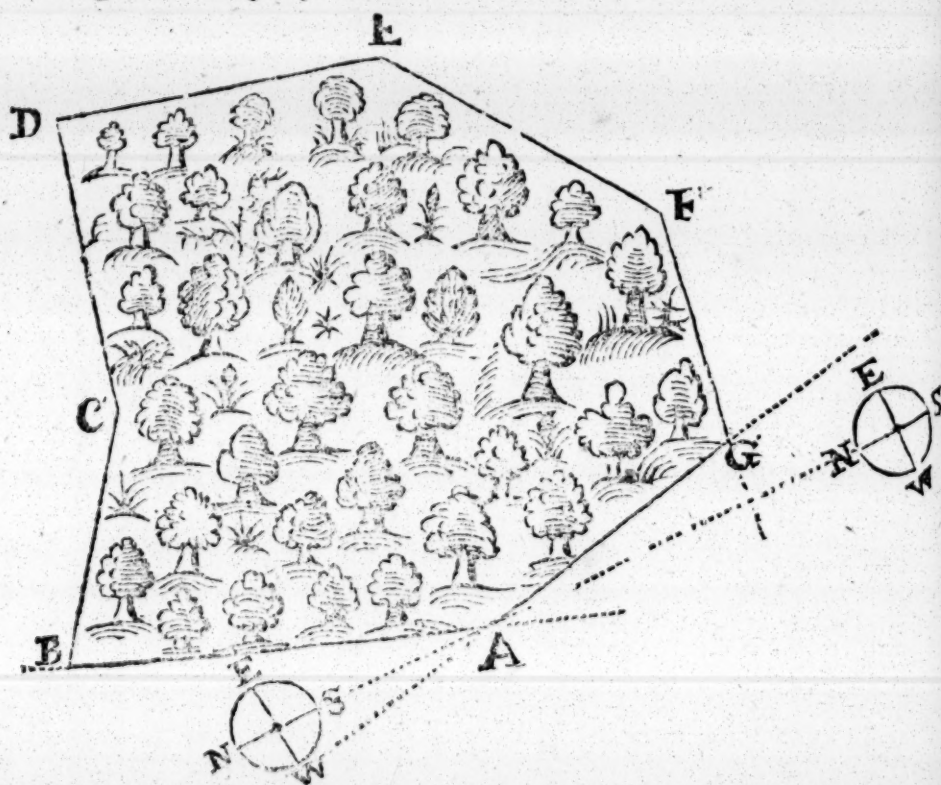
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found the place for B, there make an angle of 51 degrees, drawing the line 'till it intersect AC, &c.

You may also survey a field after this manner, by setting up a mark in the middle thereof, and measuring from that to any one angle ; also in the observations round the field, having respect to that mark, as you had here to the angle A.

It is too tedious to give examples of all the varieties; besides it would rather puzzle than instruct a *neophyte*.

To take the plot of a large field or wood, by measuring round the same and taking observations at every angle thereof by the semicircle.



Suppose

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Suppose ABCDEFGA to be a wood through which you cannot see to take the angles, as before directed, but must be forced to go round the same; first plant the semicircle at A, and turn the north end of the diameter about, 'till through the fixed sights you see the mark at B; then move round the index, 'till through the sights thereof you espy G, the index there cutting upon the limb, suppose 146 degrees.

2. Remove to B; and as you go, measure the distance AB, viz. 23 chains, 40 links; and planting the instrument at B, direct the north end of the diameter to C, and turn the index round to A, it then pointing to 76 degrees.

3. Remove to C, measuring the line as you go, and setting your instrument at C, direct the north end of the fixed diameter to D, and turn the index till you espy B, and the index then cutting 205 degrees; which, because it is an outward angle, you may mark thus γ in your field book.

4. Remove to D, and measure as you go; then placing the instrument at D, turn the north end of the diameter to E, and the index to C, the quantity of the angle will be 84 degrees.

And thus you must do at every angle round the field, and at E, you will find the quantity of that angle to be 142 degrees, at F 137, at G 110: but there is no need for taking the last angle, or measuring the two last sides, unless it be to prove the truth of your work; which is however convenient. When you have thus gone round the wood or field, you will find your field-book to be as followeth:

Angles

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Angles.		Links.	
Degr	Min.	Ch.	Link.
A .	146 . 00	A B .	23 . 40
B .	76 . 00	B C .	15 . 20
C .	205 . 00	C D .	17 . 90
D .	85 . 00 ⁷	D E .	20 . 60
E .	142 . 00	E F .	13 . 60
F .	137 . 00	G A .	19 . 28
G .	110 . 00		

To protract this, draw with a black lead pencil, a line at pleasure, as A B ; upon which set off the distance, as you see in your field-book, 23 chains, 40 links, from A to B ; then laying the center of your protractor upon A, and the diameter along the line A B, with the north end, or that of 00 degrees towards B ; on the outside of the limb make a mark against 146 degrees, through which from A draw the line A G ; so you have the first angle and first distance.

2. Place the center of the protractor upon B, and turn it about till 76 degrees lie upon the line A B ; there hold it fast, and against the north end of the diameter make a mark, through which draw a line, and set off the distance B C, 15 chains, 20 links.

3. Apply the center of the protractor to C, (the semicircle thereof outward, because you see by the field-book it is an outward angle) and turn it about till 205 degrees lie upon the line C B ; then against the upper or south end of the diameter make a mark, through which draw a line, and set off 17 chains, 90 links from C to D.

4. Put

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4. Put the center of the protractor to D, and make 84 degrees thereof lie upon the line CD; then making a mark at the end of the diameter, or 0 *degr.* through that mark draw a line, and set off 20 chains, 60 links for DE.

5. Move the protractor to E, and make 142 *degr.* to lie upon the line ED. Then at the end of the protractor make a mark as before, and setting off the distance 18 chains, 85 links, draw the line EF.

6. Lay the center of the protractor upon F, and making 137 *degr.* lie upon the line EF; against the end of the diameter make a mark, through which draw the line FG, which will intersect the line AG as at G: so you have a true copy of the field or wood. But you may, if you think fit to prove your work, set off the distance from F to G; and at G apply your protractor, making 110 *degr.* thereof to lie upon the line FG. Then if the end of the diameter point directly to A, and the distance be 90 chains, 28 links, you may be sure you have done your work true.

Whereas I bid you put the north end of the instrument and of the protractor towards B, it was chiefly to shew you the variety of working by one instrument; for in the figure before this, I directed you to do it the contrary way; and in this figure, if you had turned the south end of the instrument to G, and with the index had taken B, and so of the rest, the work would have been the same; remembering still to use the protractor the same way as you did your instrument in the field.

Also if you had been to have surveyed this field or wood by the help of the needle; after you had planted the semicircle at A, and posited it, so that

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the needle might hang directly over the *flower-de-luce* in the card, you should have turned the index to B, and put down in your field-book what degrees upon the brass limb had then been cut thereby, which, for example, suppose 20. Then moving your instrument to B, make the needle hang over the *flower-de-luce*, and turn the index to C, and note down what degrees are there cut. So do by all the rest of the angles. And when you come to protract, you must draw lines parallel to one another cross the paper, not farther distant than the breadth of the parallelogram of your protractor; which shall be meridian lines, marking one of them at one end N. for the north, and at the other S. for south. This done chuse any place which you shall think most convenient upon one of the meridian lines for your first angular point, as at A; and laying the diameter of your protractor upon that line, against 20 *degr.* make a mark; through which draw a line, and upon it set off the distance from A to B.

In like manner proceed with the other angles and lines, at every angle laying your protractor parallel to a north and south line; which you may do by the figures graduated thereon, being at either end alike.

When you have surveyed after this manner, to discover before you go out of the field, whether you have wrought true or not.

*Add all the observed angles together in the preceding example of measuring the wood, they make 900. Multiply 180 by a number less by two than the

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the number of angles ; and if the product be equal to the sum of all the angles, then you have wrought true. There were seven angles to that wood, therefore multiply 180 by 5, and the product is 900.

If you survey, by taking the quantity of every angle, and if all be inward angles, you must work as before. But if one or more be outward angles, you must subtract them out of 180 *degr.* and add the remainder only to the rest of the angles. And when you multiply 180 by a sum less by 2 than the number of your angles, you are not to account the outward angles into the number. Thus, in the last examples, I find one outward angle, *viz.* C 205 ; the quantity of which, if it had been taken, would have been but 155 *degr.* That taken from 180 *degr.* there remains 25 ; which I add to the other angles, and they make in all 720. Now because C was an outward angle, I take no notice of it ; but see how many other angles I have, and I find 6 : a number less by two than 6, is 4 : by which I multiply 180, and the product is 720, and consequently the work is right.

Directions to measure parallel to a hedge, (when you cannot go into the hedge itself ;) and also, in such case, how to take your angles.

It is impossible for you, when you have a hedge to measure, to go on the top of the hedge itself ; but if you go parallel thereto, either within or without, and make your parallel line of the same length as the line of your hedge, your work will be the same.

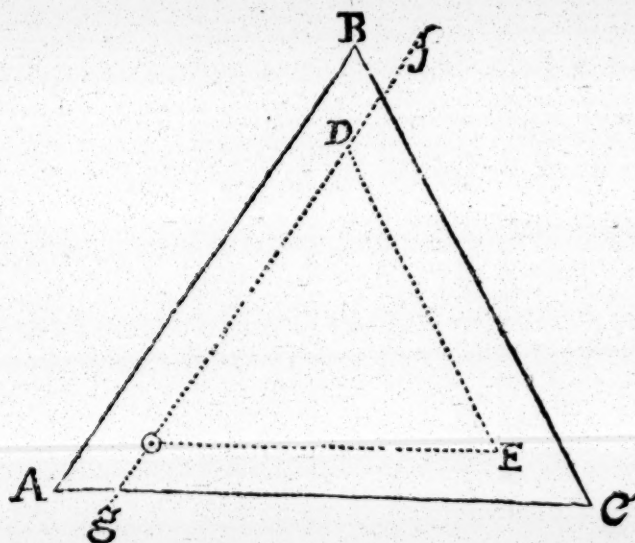
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same. Thus, if A B was a bushy hedge, to which



you could not conveniently come nigher to plant your instrument than $\odot$; let him that goes to set up your mark at B, take before he goes the distance A $\odot$, which he may do readily with a wand or rod; and at B let him set off the same distance again, as to $+$, where let the mark be placed for your observation; and when the chain bears, measure the distance $\odot +$; be sure they have respect to the hedge A B, so as that they make $\odot +$ equal to AB, or of the same length.

But to make this more plain: suppose A B C to be a field; and for the bushes, you cannot come nigher than $\odot$ to plant your instrument. Let him



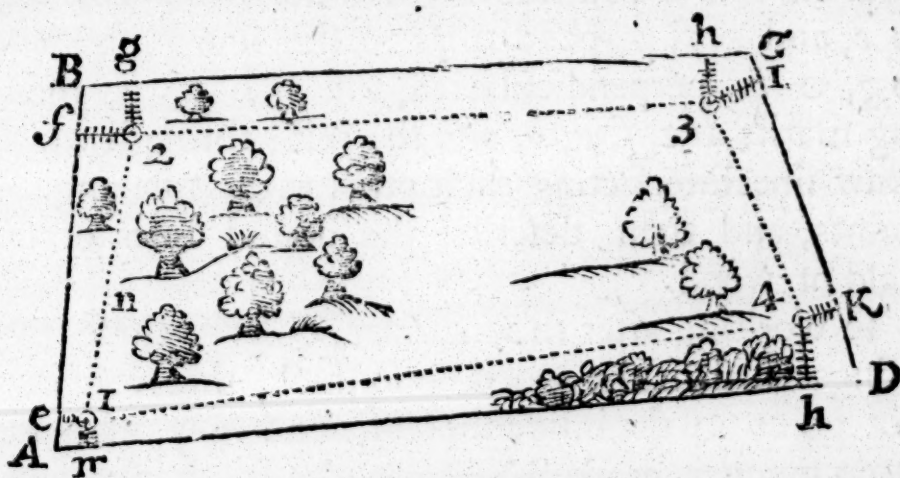
that sets up the marks take the distance between the instrument $\odot$, and the hedge A B; which distance let him set off again nigh B, and set up his mark at D like

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likewise let him take the distance between the $\odot$ and the hedge A C, and accordingly set up his mark at E. Then taking the angle D $\odot$ E, it will be the same as the angle B A C: so do for the rest of the angles. But when the lines are measured, they must be measured of the same length as the outside lines, as the line $\odot$ D measured from g to f, &c. The best way, therefore, is for those who measure the lines, to go round the field on the outside thereof, although the angles be taken within.

To take the plot of a field or wood, by observing near every angle, and measuring the distance between the marks of observation, by taking in every line, two off-sets to the hedge.

Let A, B, C, D, be a wood or field, to be thus measured. Cause your assistants to set up marks in



every angle thereof, not regarding the distance from the hedges, so much as the convenience for planting

H

ing

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ing the instrument, so as you may see from one mark to another. Then beginning at $\odot 1$, take the quantity of that angle, and measure the distance 1, 2. But before you begin to measure the line, take the off-set to the hedge, *viz.* the distance $\odot e$; and in taking of it, you must make that little line $\odot e$ perpendicular to 1, 2; which is easily done, when your instrument stands with the fixed sights towards 2, by turning the moveable index 'till it lie upon 90 *degr.* which will then direct to what place of the hedge to measure, as *e*, that little line $\odot e$, set down in your field-book under title *Off-set*. So likewise when you come to 2, measure there the off-set again *viz.* $\odot f$. Then taking the angle at 2, measure the line 2, 3, and the off-sets 2 *g*, 3 *b*. The like do by all the rest of the lines and angles in the field. And when you come to lay these down upon paper; first, as you have been taught before, protract the figures 1, 2, 3, 4. That done, set off your off-sets as you find them in the field-book, *viz.* $\odot e$, and $\odot f$, perpendicular to the line 1, 2; also $\odot g$, $\odot b$, perpendicular to the line 2, 3, making marks at *e*, *f*, *g*, *b*, and the rest; through which draw lines intersecting each other at the true angular points, and then describe the bound lines of the field or wood.

In working after this manner, observe these two things: first, if the wood be so thick, that you cannot go on in the inside thereof, you may, after the same manner, as well perform the work by going on the outside round the wood.

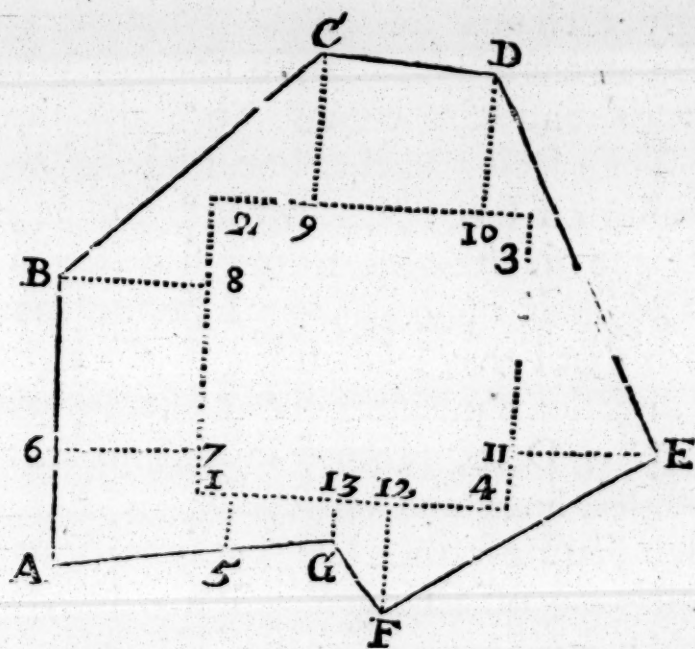
Secondly, If the distances are so great, that you cannot see from angle to angle, cause your assistant

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to set up a mark as far from you as you can conveniently see it, as at *n*. Measure the distance $\odot 1 n$, and take the off-set from *n* to the hedge. Then at *n* turn the fixed sights of the instrument to $\odot 1$, and by that direction proceed on the line 'till you come to an angle.

This way of surveying is made easier (though I cannot say truer) by taking only a great square in the field; from the sides of which the off-sets are taken.

I have drawn this following figure so, that at once you may see all the variety of this way of working. The best way, indeed, is to contrive your



square so, that if possible, you may, from the sides thereof, go upon a perpendicular line to any of the angles. But if that cannot be, then perpendicular

H 2

lines

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lines to the sides may do as well, as you see here, 15 and 76 are. To begin, therefore, plant your semicircle in any convenient part of the field, as at 1, for taking a large square; and laying the moveable index upon 90 *degr.* look through the sights, and cause a mark to be set up in that line, as at 4: looking also through the fixed sights, cause another mark to be set up, as at 2. Measure out from your instrument towards either of these marks, any number of chains as 12 from 1 to 2; from 2 to 4, 12 chains. But as you measure, remember to take the off-sets in a perpendicular line to every angle or side, if there be occasion, as here 17, which is 1 chain, 50 links; from my stations I take an off-set to a side of the hedge, as 76, and put it down accordingly 5 chains, 40 links. So at 8 I take an off-set to an angle *viz.* 8 B, 6 chains; which off-set is at the end of 8 chains, 30 links in my first line. Then seeing in that line there is no farther occasion for off-sets, I plant my instrument at 2, and I direct the fixed sights to my first station; then laying the index upon 90 *degr.* I cause a mark to be set up, so that I may see it through the sights; and in that direction I measure out 12 chains, taking the off-sets C 9, D 10, proceed in like manner for the other angles, lines, and off-sets.

When you have thus laid out your square, and taken all your off-sets, you will find in your field-book such *memorandums* as the following, to help you to protract.

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The angles 4 right angles.

The sides 12 chains, 00 links each.

I went round *cum solis*, or the hedges being on my left hand.

	C.	L.		C.	L.
In the first	1	50	Off-set to a side-line	5	40
line at	8	30	Off-set to an angle	6	00

	C.	L.		C.	L.
In the second	3	50	Off-set to an angle	6	00
line, at	10	70	Off-set to an angle	5	50

	C.	L.		C.	L.
In the third	10	00	Off-set to an angle	5	30
line, at					

	C.	L.		C.	L.
In the fourth	4	33	Off-set to an angle	4	40
line, at	6	70	Off-set to an angle	1	50
	10	80	Off-set to a side	2	20

Now to lay down upon paper the foregoing work, make first a square figure, as 1, 2, 3, 4, whose side may be 12 chains. Then considering you went with the sun, take 1, 2 for the first line; and taking from your scale 1 chain, 50 links, set it upon the line from 1 to 7; at 7 raise a perpendicular, as 7, 6, making it according to your field-book, 5 chains, 40 links long. Also for the second off-set upon the same line, take from your scale of equal parts 8 chains,

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chains, 30 links, which set upon the line from 1 to 8, and upon 8 make the perpendicular line 8 B, 6 chains in length.

For the off-sets of the second line, take 3 chains 50 links from the scale, and set it from 2 to 9; at 9 make a perpendicular line 6 chains long, viz. 9 C; also for the second off-set of the same line, take 10 chains, 70 links, and set it from 2 to 10; at 10 make the perpendicular 10 D, 5 chains, 50 links in length.

For the off-sets of the third line, take from your scale 10 chains, and set it up from 3 to 11; and at 11 make the perpendicular 11 E, 5 chains, 30 links long.

For the off-sets of the fourth line, take from your scale 4 chains, 30 links, and set it from 4 to 12; and at 12 make the perpendicular 12 F, 4 chains 40 links long. Also take 6 chains, 70 links, and set it from 4 to 13; and at 13 make the perpendicular 13 G, 1 chain, 50 links long.

Lastly, Take 10 chains, 80 links, and set it from 4 to 1; and at 1, make the perpendicular 1, 5, 2 chains 20 links long.

Then have you no more to do, but through the ends of these perpendiculars to draw the bounding-lines, remembering to make angles where the field-book mentions angles; and where it mentions side-lines, there to continue such side-lines 'till they meet in an angle:

Although I mention a square, yet you are not obliged to take that figure; for you may with the same success use a parrallelogram, triangle, or any other figure. Nor are you bound to take the off-sets

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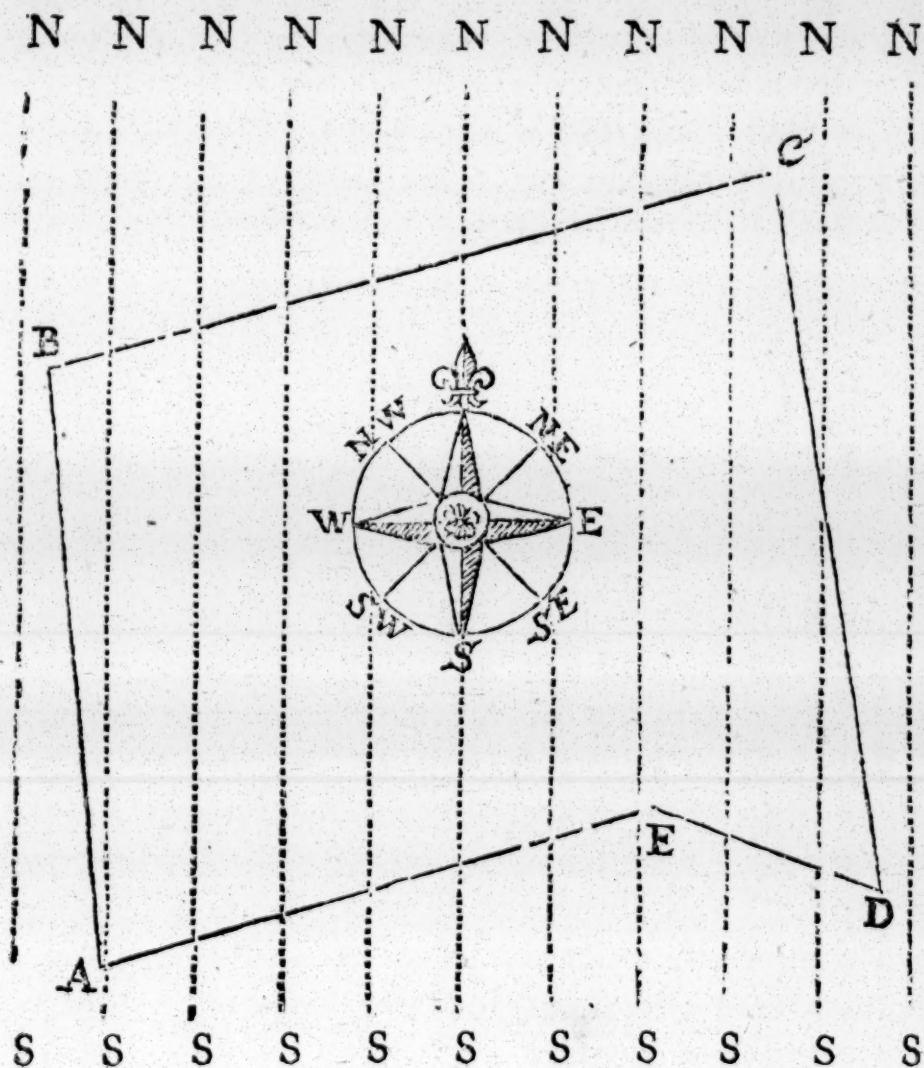
sets in perpendicular lines, notwithstanding it is the best way; for you may take the angles with the index from any part of the line.

This way was chiefly intended for such as were not provided with proper instruments; for with the cross staff only, you may lay out a square, the rest of the work being done with a chain.

By the help of the needle to take the plot of a large wood, by going round the same, and making use of that division of the card that is numbered with four 90° or quadrants.

Let A B C D E A represent a wood; set your instrument at A, and turn it about, 'till through the fixed sights you espy B, then observe what degrees in the division before spoken of, the needle cuts; which suppose 7 degrees from N. towards West, measure A B 28 chains, 20 links; then setting the instrument at B, direct the sights to C, and see what then the needle cuts, which let be 74 degrees from N. towards the E; measure B C 39 chains, 50 links; in like manner measure every line, and take every angle, and then your field-book will stand thus, as followeth hereunder,

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Links.	Chains.	Minutes.	Degrees.		Lines.
20	28	00	7	} to the	AB NW
50	39	00	74		BC NE
00	38	00	9		CD SE
55	14	20	63		DE NW
60	28	80	74		EA SW

to the

To

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To lay down which upon paper, draw parallel lines, as N. S. N. S. &c. to represent meridians, or north and south lines, then applying the protractor (which should be graduated accordingly with twice 90 degrees, beginning at each end of the diameter, and meeting in the middle of the arch) to any convenient place of one of the lines as to A, lay the meridian line of the protractor to the meridian line on the paper, and against 7 *degr.* make a mark, through which draw a line, and set off thereon the distance A B 28 chains 20 links. *Secondly*, Apply the center of the protractor to B, and (turning the semicircle thereof the other way, because you see the course tends to the eastward) make the diameter thereof lie parallel to the meridian lines on the paper (which you may do by the figures at the ends of the parallelogram) and against 74 degrees make a mark, and set off 39 chains, 50 links, and draw the line B C; the like do by the other lines and angles, until you come round to the place where you began.

This is the general method of plotting observations, taken after this manner, used by most surveyors in *America*, where they lay out very large tracts of land: but there is another way much surer, yet rather tedious, (I think first made public by Mr. *Norwood*) whereby you may know before you come out of the field, whether you have taken your angles, and measured the lines truly or not, and is as follows:

When you have surveyed the ground as above directed, and find your field-book to stand as before, casting up what northing, southing, easting, or west-
ing

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ing every line makes; that is to say, how far at the end of every line you have altered your meridian, and what distance upon a meridian line you have made. As for example: suppose AB, equal to 20 chains, was the side of a field, NS a meridian line, the angle



CAB north 20 *deg.* east. The business is to find the length of the line AC, which is called the north-
ing, or the difference of latitude; also the length of
the line CB, which is called the easting, or differ-
ence of longitude; which you may do indifferently
true, by laying them down upon paper. By help
of the *Gunter's* scale, the best way is by the tables
of sines and logarithms, using this proportion:

As radius or sine of 90 degrees, *viz.* the right
angle C is to the logarithm of the line AB 20
chains;

So is the sine of the angle CAB 20 degrees to
the difference of longitude CB 6 chains 80 links.

Secondly, To find the difference of latitudes, or
the line AC, say,

As radius is to the logarithm of the line AB 20
chains, so is the sine complement of the angle at A,
to the logarithm of the line AC 18 chains, 80
links.

EXAMPLE.

E X A M P L E.

I find by my field-book, the first line (see the last figure but one) runs N. W. 7 degrees, 28 chains, 20 links; now to find what northing, and what westing is hereby made, I say thus :

As radius	10,000000
Is to the logarithm of the line 28 } chains, 20 links	1,450249
So is the sine of the angle from } the meridian, viz. 7 degrees,	9,085894
To the logarithm of the westing } 3 chains, 43 links,	10,536143

Again,

As radius,	10,000000
Is to the logarithm 28 chains, 20 links	1,450249
So is the sine complement of 7 degrees	9,996751
	—————
To the logarithms of the northing 27 } chains, 99 links,	11,447000

And having thus found the northing and westing of that line I put it down in the field-bok against the line under the proper titles N. W. in like manner I find the latitude and longitude of all the rest; and having set them down, the field-book will appear thus :

Lines.

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	Lines.	Degrees.	Chains. Minutes.	Links.	N	S	E	W
AB : NW	7 : 00	28 : 20	27 : 90	.. : ..	.. : ..	03 : 43		
BC : NE	4 : 00	39 : 50	10 : 86	.. : ..	37 : 97	.. : ..		
CD : SE	9 : 00	38 : 00	.. : ..	37 : 53	05 : 95	.. : ..		
DE : NW	63 : 00	14 : 55	06 : 53	.. : ..	.. : ..	13 : 00		
EA : SW	74 : 00	28 : 60	.. : ..	07 : 88	.. : ..	27 : 49		
					45 : 41	45 : 41	12 : 02	43 : 02

This done, add the northings together, also all the southings, and see if they agree; also all the eastings and westings; and if they agree likewise, then you may be sure you have wrought truly, otherwise not. Thus in the example the sum of the northings is 45 chains, 41 links; so likewise is the sum of the southings; also the sum of the eastings is 43 chains, 92 links, so is the sum of the westings: therefore I say I have surveyed that piece of land true.

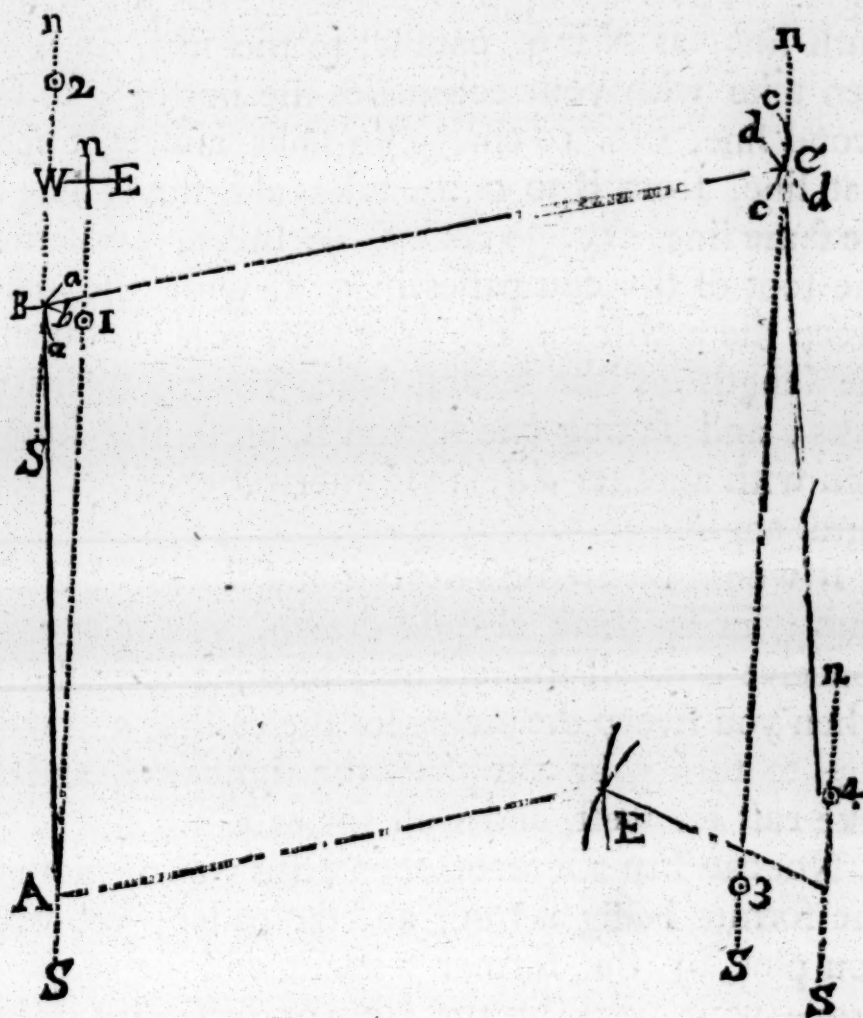
But because this way of casting up the northing, southing, easting, and westing of every line, may seem tedious and troublesome, I have at the end of this book added a table, wherein, by inspection, you may find the longitude and latitude of every line, according to the angle which it makes with the meridian.

Another way of plotting the foregoing piece of ground according to the table in the field-book, with regard to the points of the compass, N. S. E. and W. is as follows:

Draw

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Draw an indefinite right line, as $n \odot A S$ for a meridian line ; then beginning in any place of that



line as from A to $\odot 1$, viz. 27 chains, 99 links ; then taking with your compasses the westings of the same line, viz. 3 chains, 43 links ; set one foot in $\odot 1$, and with the other describe the arch aa ; next take the length of your first line, as you find it in the field-book, viz. 28 chains, 20 links, and setting one foot of the compasses in A, with the other cross

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cross the former arch *aa* with another arch *Bb*, and in *B* the intersection of these arches is your second angle. Then through *B* draw another north and south line, as *NBS*, parallel to the first, *NAS*; then take with your compasses the northing of the second line, viz. 10 chains 89 links, and set it upon that line, from *B* to *o 2*; take also the easting of the same line, viz. 37 chains, 97 links; and setting one foot of the compasses in *o 2*, with the other sweep the arch *cc*; also take with your compasses the length of the second line, viz. 39 chains 50 links; and setting one foot in *B*, cross the former arch with another *dd*; the intersection *C* is your third angle.

It would be needless to go round thus with all the lines; for by these already drawn, you may easily conceive how all the rest may be done. But observe when you sweep the arches for the easting and westing, to turn your compasses the right way, and not take east for west, and west for east.

Nor can I much recommend this way of plotting, the former being as true, and far easier; yet when you plot by the former way, it will be proper to prove your work by the table of difference of latitude and longitude, before you begin to protract; and when you find your field-book correct, you may lay down your work upon paper, by that method you think the easiest.

To conclude this chapter or section, I shall in the next place shew you, how to survey a field by the chain only, using no other instrument, and that after a better manner than hitherto has been taught.

First,

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First, therefore, I shall shew you how to take the quantity of an angle by the chain; (which being well understood) there will be no more required; for the business of a surveyor in the field, is no more than to measure sides and take angles, in order to find how many acres any field or piece of land contains.

To take an angle in the field by help of the chain only.

First measure along the hedge A B, any small distance, as two chains from A to 2; also measure



along

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along the hedge A C any number of chains you please, (either equal to the former or not) as A 3 two chains; next measure the distance 2, 3, equal to 1 chain, 68 links; and then have you done in the field. To plot which draw the line A B at pleasure, and set off 2 chains from A to 2; then take with your compasses the distance A 3, viz. 2 chains, and setting one foot in A, describe the arch 2 3; take also with your compasses the distance 2 3, viz. 1 chain, 68 links; and setting one foot in 2, with the other cross the former arch in A, draw the line A 4 3 C; which with A B, will make an angle equal to the angle in the field.

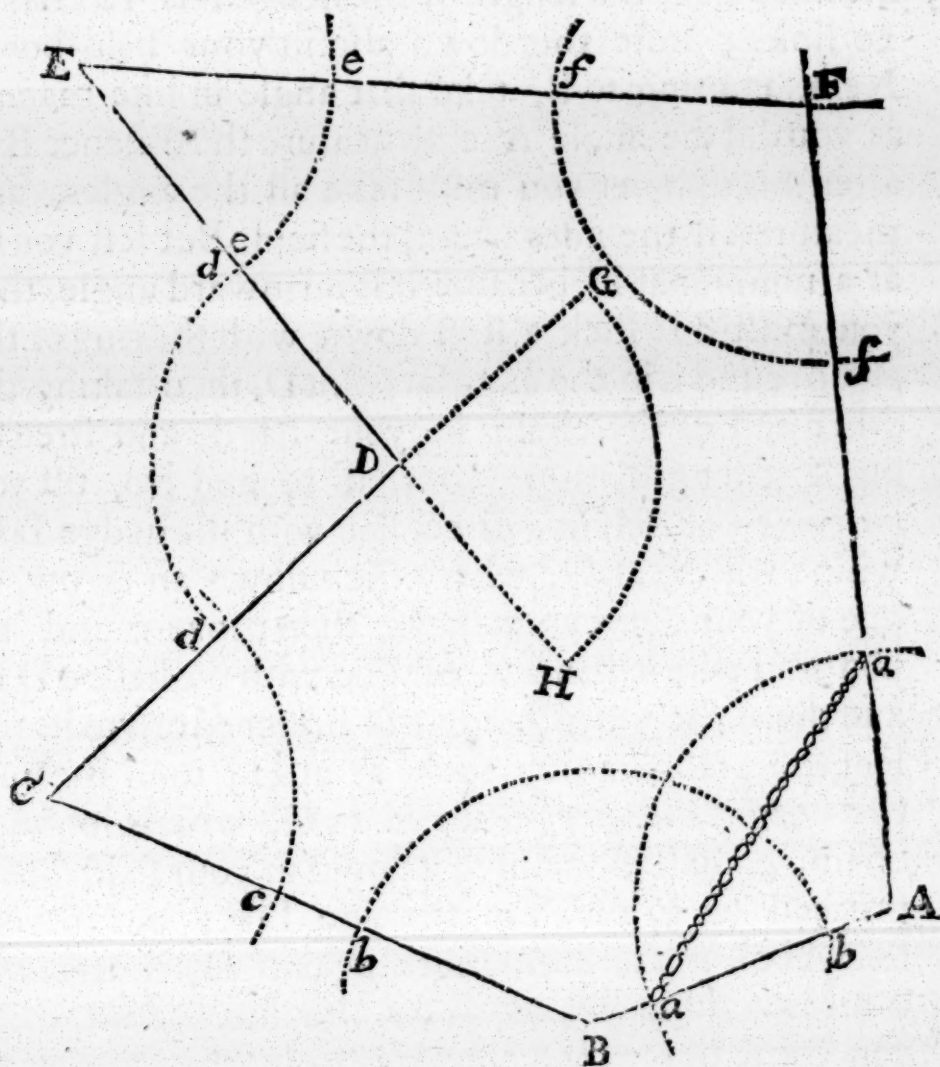
A more easy and speedy way is to measure out one chain only along the hedges thus; I set a strong stick in the angle A, and putting the ring which is at one end of the chain over it, I take the other end in my hand, and stretch out the chain along the first hedge A B, and where it ends, as at 5, I stick down a stick; then I stretch the chain also along the other hedge A C, and at the end thereof set another stick as at 4; then loosing my chain from A, I measure the distance 4, 5, and find it 74 links, which is all I need note down in my field-book for that angle, and now coming to plot it, I first take from my scale the distance of one chain, and placing one foot of the compasses in any part of the paper, as at A, I describe the arch 4, 5; then I take from the same scale 74 links, and set it off upon that arch, making marks where the ends of the compasses fall, as at 4 and 5. *Lastly*, From A; through these marks I draw the lines A B, and A C, which constitute the former angle: always plot your angles with

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with a very large scale ; but your lines may be set off with a smaller.

I shall give you two *Examples* of this way of measuring, and then leave you to your own practice. First,

To survey a field with the chain only, by going round the inside of it.



Let ABCDEFA be the field ; and beginning at the angle A in that point, stick down a staff through
I the

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the great ring at one of the ends of your chain, and taking the other end in your hand, stretch out the chain in length, and see in what part of the hedge A F, the other end falls; as suppose at a , there set up a stick; and do the like by the hedge AB, and let the chain end at (a) also: measure the nearest distance between a and a , which admit to be 1 chain 60 links: this note down in your field-book: measure next the length of the hedge AB, 12 chains, 50 links; note this down also in your field-book. Next, coming to B, take that angle in like manner as you did the angle A. and measure the distance BC: after this manner you must take all the angles, and measure all the sides round the field. But lest you be at a nonplus at D, because it is an inward angle, thus you must do: stick a staff down with the ring of the chain round it in the angular point D, then taking the other end of the chain in your hand and stretching it at length, move yourself to and fro, till you perceive yourself in a direct line with the hedge DC, which will be at G; where stick down an arrow, or one of your surveying-sticks, then move round 'till you find yourself in a direct line with the hedge DE; and there the chain being still stretched out to its full length, plant another stick, as at H; then measure the nearest distance, from H to G, which let be 1 chain, 43 links; and note it down in your field-book; proceed on to measure the line DE; but in your field-book make some mark against D, to signify it is an inward angle, as ∇ , or the like. And when you come to plot this, you must plot the same angle outward that you took inward; for the angle GDH is the same as the angle $d D d$. If you survey a wood,

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wood, by going round it on the outside, then the angle $d D d$ is an outward angle.

Having thus taken all the angles and measured all the sides; the next thing to be done, is to lay them down upon paper, according to your field-book; which you will find to stand thus:

Cross Lines or Chords.			Lines of the Field.	Chains.	Links.
Distances from the angular points.	Chains.	Links.			
$a a$	1	60	A B	12	50
$b b$	1	84	BC	23	37
$c c$	1	06	CD	19	30
$d d$	1	43 ⁷	DE	20	00
$e e$	0	80	E F	29	00
$f f$	1	52	F A	31	50

It being more convenient that the angles should be made by a greater scale than the lines are laid down with; I have therefore in this figure, made the angles by a scale of one chain in an inch, and laid down the lines by a scale of ten chains in one inch. Now to begin to plot, take from your large scale one chain; with that distance, in any convenient place of your paper, as at A, sweep the arch $a a$; then from the same scale take off 1 chain, 60 links, and set it upon that arch, as from a to a ; and draw through the point, a and a , the right lines A B,

I 2
A F:

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A F: then repairing to your shorter scale, take from thence the first distance, *viz.* 12 chains, 50 links; and setting it from A to B, draw the line A B.

Secondly, Repairing to B, take from your large scale one chain, and setting one foot of the compasses in B, with the other describe the arch *bb*; also from the same scale take your chord line, *viz.* 1 chain, 84 links, and set it upon the arch *bb*, having one foot of the compasses in the point where the arch intersects A B, the other will fall at *b*; then through *b* draw the line B C; and from your smaller scale set off the distance 23 chains, 37 links, from B to C, where the next angle must be made. After this manner proceed on according to your field-book, till you have done.

And here note, That you need neither in the field, nor in plotting upon the paper, take any notice of the angle F, nor yet measure the lines E F or A F; for those two lines being drawn, will intersect each other at the true angular point F: however for proof of the work, it is proper to measure them, and likewise to take the angle in the field.

I must not omit in this place to shew you the usual way taught by surveyors for measuring a field by the chain only: as true indeed as the former, but more tedious, which is as follows:

The common way taught by surveyors for taking the plot of the foregoing, or any other field.

In order that you may not be confused with too many lines in one figure, I have here again placed
the

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	Chains.	Links.
A C	33	70
A D	25	70
A E	45	40

To plot which, first draw a right line A C at pleasure, and set off thereon 33 chains, 70 links, according to your field-book, for the first diagonal; then taking with your compasses the length of the line A B, *viz.* 12 chains, 50 links set one foot in A, and with the other describe the arch *aa*; also take the line B C, *viz.* 23 chains, 37 links, and setting one foot in C, with the other describe the arch *cc*, cutting the arch *aa* in the point B; then draw the lines A B, C B, which shall be the two bound-lines of the field.

Secondly, Take with your compasses the length of the diagonal A D, *viz.* 25 chains 70 links, and setting one foot of the compasses in A, with the other describe the arch *dd*; also taking the line C D, *viz.* 19 chains, 30 links, set one foot in C, and with the other describe the arch *ee*, cutting the arch *dd* in the point D, to this intersection draw the line C D.

Thirdly, Take with your compasses the length of the diagonal A E, *viz.* 45 chains, 40 links; and setting one foot in A, with the other describe an arch, as *ff*; also take the line D E, 20 chains, and therewith cross the former arch in the point E, and draw the line D E.

Lastly,

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Lastly, Take with your compasses the length of the line A F, viz. 31 chains, 50 links; and setting one foot in A, describe an arch, as II. Also take the length of the line E F, viz. 29 chains, 00 links; and therewith describe the arch *bb*, to cut the arch II in the point F; draw the lines A F and E F, and so will you have a true figure of the field.

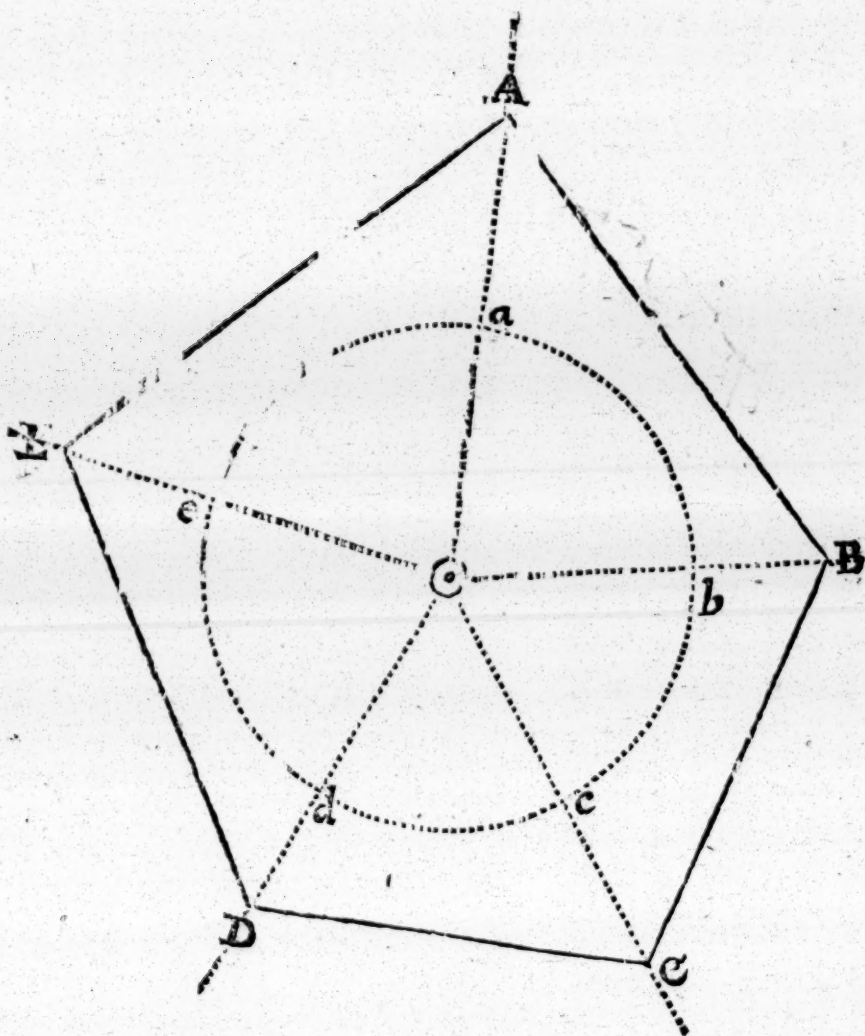
I have shewed you both ways, that you may take your choice. And now I proceed to my second example promised.

To take the plot of a field at one station, near the middle thereof, by the chain only.

Let ABCDEA be the field, $\odot$ the appointed place, from whence by the chain to take the plot thereof. Stick a stake down at $\odot$ through one ring of the chain, and make your assistant take the other end and stretch it out. Then cause him to move up and down, till you see him exactly in a line between the stick and the angle A; there let him set down a stick, as at *a*, and be sure that the stick *a* be in a direct line between $\odot$ and A; which you may easily perceive by standing at $\odot$, and looking to A. This done, cause him to move round towards B: and at the chain's end, let him there stick down another stick exactly in the line between $\odot$ and B, as at *b*. Afterwards let him do the same at *c*, at *d*, and at *e*; and if there were more angles, let him plant a stick at the end of the chain in a right line between $\odot$ and every angle. In the next place measure the highest distance between stick and stick, as

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ab, 1 chain, 26 links; *bc*, 1 chain, 6 links; *cd*, 1 chain 0 links; *de*, 1 chain, 20 links; and put



them down in your field-book accordingly. Measure also the distances between $\odot$ and every angular point as $\odot$ A, 18 chains, 10 links; $\odot$ B, 15 chains, 0 links, &c. all which being put down, your field-book will appear thus :

Subtend-

Divers Ways to take the Plots of Fields. 121

	Ch.	Link.		Chain.	Link.
Subtending or chord- lines.	<i>a b</i>	1 . 26	Diagonal or center lines.	⊙ A	. 18 . 10
	<i>b c</i>	1 . 06		⊙ B	. 15 . 00
	<i>c d</i>	1 . 00		⊙ C	. 17 . 00
	<i>d e</i>	1 . 20		⊙ D	. 15 . 00
				⊙ E	. 16 . 00

To Plot the field by these observations.

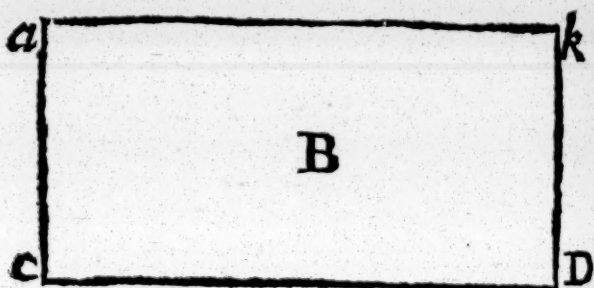
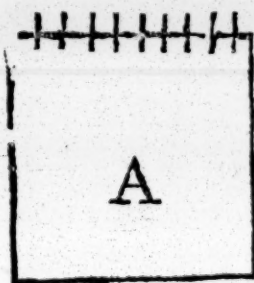
Take from a large scale 1 chain, and setting one foot of the compasses in any convenient place of the paper, as at ⊙, make the circle *a b c d e*; then taking for your first subtendent, or chord-line, 1 chain, 26 links, set it upon the circle, as from *a* to *b*. From ⊙ through *a* and *b* draw lines, as ⊙ A ⊙ B, which produce as far as may be convenient. Then take your second subtendent from the same large scale, viz. 1 chain, 6 links, and set it upon the circle from *b* to *c*, and through *c* draw the line ⊙ C. When you have thus set off all your subtendents, and drawn lines through their several marks, take a smaller scale; and upon the lines already drawn, set off the diagonal or center lines, as you find them in the field-book: thus upon the line ⊙ *a* A set off 18 chains, 10 links, from ⊙ to A; upon the line ⊙ *b* B, 15 chains, 0 links, from ⊙ to B; and so by all the rest. Lastly, Draw the lines A B, B C, C D, &c. and the work is finished.

C H A P. VII.

To find the content of a plot of land.

HAVING by this time sufficiently shewed you how to survey a field, and lay down a true figure thereof upon paper ; I come in the next place to teach you how to cast up the contents thereof ; that is to say, to find out how many acres, roods, and perches it contains. And first,

Of the square and right angled parallelogram.



To cast up either of which, multiply one side by the other, and the product will be the content.

E X A M P L E.

Let A be a true square, each side being ten chains; multiply 10 chains 0 links, by 10 chains 0 links, *facit* 10|00000 ; from which I cut off the five last figures, and there remains just 10 acres for the square A.

How to cast up the Contents, &c. 123

Again ; In the parallelogram B, let the side *a k* or *c D* be 20 chains, 50 links ; and the side *a c* or *k D* 10 chains, 0 links : multiply *a k* 20 chains, 50 links, by *a c* 10 chains 0 links, *facit*, 20|50000 ; from which cutting off the last five figures, remains 20 acres. Then if you multiply the figures cut off *viz.* 50000 by 4, *facit*, 200000 ; from which cutting off five figures, remains 2 roods ; and if any thing but 00 had been left, you must have multiplied again by 40 ; and then cutting off again five figures, you would have had the odd perches : see it done hereunder.

I need not have put down the multiplication by 40 ; but only to shew you in what order the figures will stand, when you have odd perches. The content of the long square B, is 20 acres, 2 roods, 00 perch.

	20	50	
		10	00
Acres—	20	5000	00
			4
Roods—	2	000	00
			40
Perches—	0	000	00

Of TRIANGLES.

The content of all triangles are found by multiplying half the base by the whole perpendicular, or the whole base by half the perpendicular ; or otherwise by multiplying the whole base and whole perpendicular together, and taking half that product for the content. Either of these three ways will do, take which you please.

E X A M-

Contents of a Plot of Land. 125

So likewise in the triangle B, the base cd is 10 chains, and the perpendicular ab 13 chains, 70 links; which multiplied by half the base, will give the same content. Also in the triangle C, if you multiply half the base Ed by the perpendicular cF , the product will be the content of the triangle.

You may let fall your perpendicular from which angle you please, taking the line it falls upon for the base. Thus in the triangle A, if from b you let fall a perpendicular, take bd , and the half of ac for finding the content. Also in the triangle C, you may from E let fall your perpendicular, and although it falls without the triangle, yet the half of EG , multiplied by the whole of cd , shall be the true content of the triangle C. Note, cd must be produced before you can let fall the perpendicular.

Remember this: all triangles have equal bases, and lying between the same parallels, are of the same content: so the triangles A, B, C, having equal bases, and lying between the parallel lines EC and Gb , are therefore of the same content.

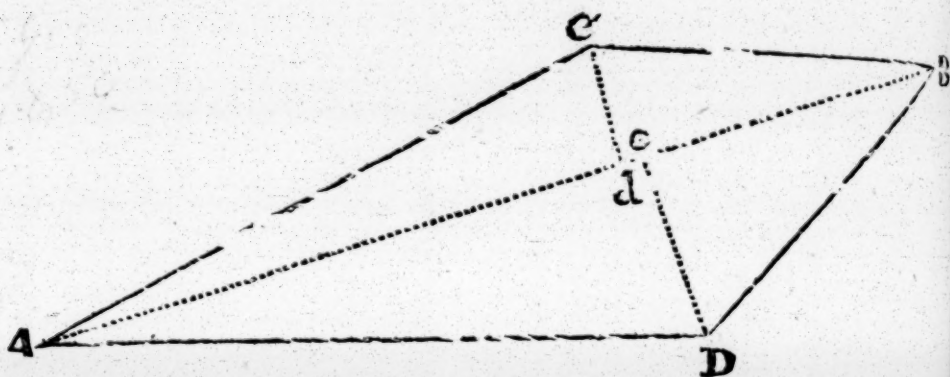
To find the content of a trapezium.

Draw between two opposite angles a strait line, as AB , then is the trapezium reduced into two triangles, *viz.* ABC and ABD , which you may measure as before taught; and adding their products together, you will have the true content of the trapezium. Or rather shorter, thus:

Take

How to cast up the

Take the length of the line A B, which let be 37 chains, 0 links ; take also the length of the



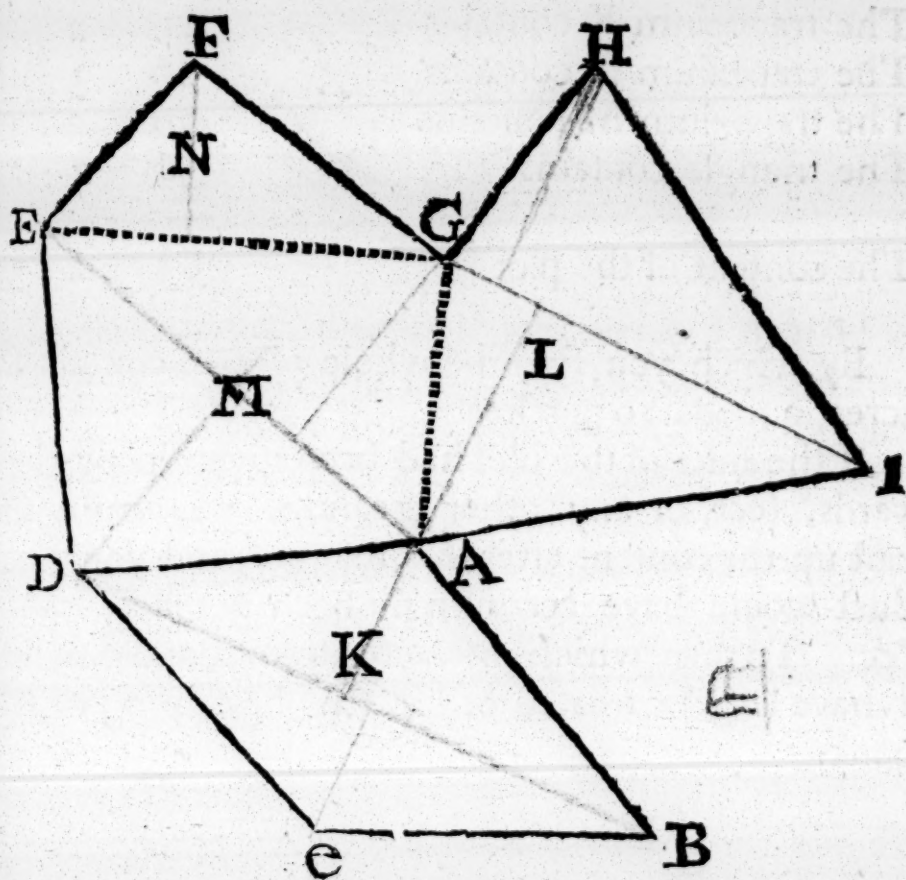
perpendicular D e, which let be 7 chains, 40 links ; also C d, 4 chains, 80 links ; add the two perpendiculars together, and they make 12 chains, 20 links ; which multiply by half the common base A B, 18 chains 50 links, and the product is 22 acres 2 roods, 11 perches as appears by the operation hereunder.

Half the common base A B	18,50
The sum of the two perpendiculars	12,20

	37000
	3700
	1850
Acres	22 57000
	4
Roods	2 28000
	40
Perches	11 20000
	To

To find the content of an irregular plot, consisting of many sides and angles.

To do this, you must first by drawing lines from angle to angle, reduce all the plot into trapezia and triangles ; after which measure every trapezium and triangle severally, and adding their contents all together, you will have the true content of the whole plot.



In

In the annexed figure ABCDEFGHI, draw the line AD, which cuts off the trapezium K; also the line AG, which cuts off the trapezium L. And lastly the line GE, which makes the trapezium M, and the triangle N, so is the whole plot reduced into the three trapeziums K, L, M, and the triangle N: all these I measure as before taught, and put them down as hereunder :

	Acres.	Roods.	Perches.
The trapezium K contains	21	2	12
The trapezium L contains	26	3	18
The trapezium M contains	30	2	16
The triangle contains	6	2	24
The content of the plot	85	2	30

By which you find the whole plot to contain 85 acres, 2 roods 30 perches.

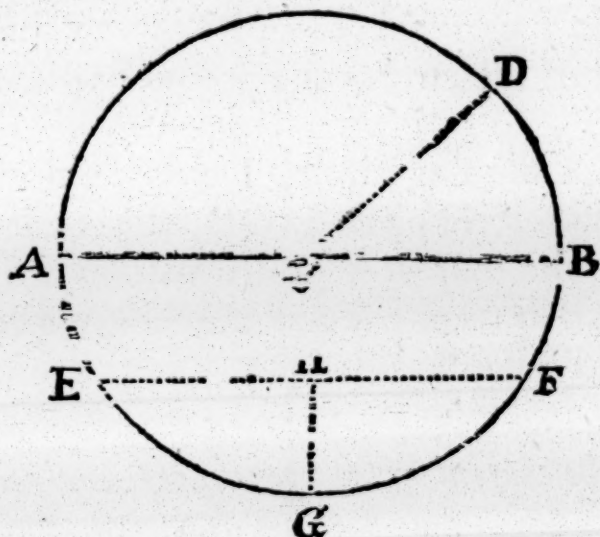
If the sides of the plot had been given in perches, yards, feet, or any other measure, you must still cast up the content after this manner, and your product would have accordingly been perches, yards, &c. To turn which into acres, roods, and perches, I have largely treated of in the beginning of this book.

To find the content of a circle, or any portion thereof.

To find the content of the whole circle, it is convenient that first you know the diameter or circumference thereof; one of which being known, the

and the other is easily found; for as 7 is to 22, so is the diameter to the circumference; and as 22 is to 7, so is the circumference to the diameter.

In this annexed figure, the diameter A B is 2 chains or 200 links; which multiplied by 22



and the product divided by 7, gives 6 chains, 28 links, and something more for the circumference. Now to know the superficial content, multiply half the circumference by half the diameter, the product will be the content; half the circumference is 3 chains, 14 links; half the diameter, 1 chain, 0 links; which multiplied together, the product is 3,1400 square links, or 1 rood, 10 perches, the content of the circle. Again,

By the diameter only to find the content.

As 14 is to 11, so is the square of the diameter to the content. The square of the diameter is

K

40000,

40000, which multiplied by 11, makes 440000; which, divided by 14, gives 31428, or 1 rood 14, perches, and something more for the content.

To measure the superficial content of a sector of a circle.

Multiply half the compass thereof by the semidiameter of the circle, the product will answer your desire.

In the foregoing circle, I would know the content of that little piece DCB; the arch DB is 78 links $\frac{1}{2}$; the half of it $39\frac{1}{4}$; which multiplied by 1 chain, 0 links, the semidiameter gives 3925 square links, or $6\frac{1}{4}$ perches.

To find the content of a segment of a circle, without knowing the diameter.

Let EFG be the segment, the chord EF, is 1 chain 70 links, or 170 links; the perpendicular GH 50 links; now multiply $\frac{2}{3}$ of the one by the whole of the other, the product will be the content nearly; the two thirds of 170 is the nearest 113, which multiplied by 50, produces 5650 square links, or 9 perches.

To find the superficial content of an oval.

The common way is to multiply the long diameter by the shorter, and observe the product; and then, as if you were measuring a circle, say,

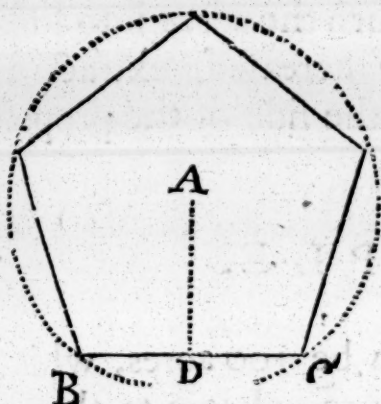
Contents of a Plot of Land. 131

As 14 to 11, so the said product to the content of the oval, but this is not exact. A better way is,

As 1, $\frac{27}{100}$ is to the length of the oval, so is the breadth to the content; or nearer, as 1,27324 to the length, so is the breadth to the content.

To find the superficial content of regular polygons; as pentagons, hexagons, septagons, &c.

Multiply half the sum of the sides by a perpendicular let fall from the center upon one of the sides, the product will be the area or superficial content of the polygon. In the following pentagon the side B C is 84 links, the whole sum of the



five sides, therefore, must be 420, the half of which is 210; which, multiplied by the perpendicular AD, 56 links gives 11760 square links for the content, or 18 perches $\frac{8}{10}$ of a perch, almost 19 perches.

I have been shorter about these three last figures than my usual method, because they very rarely fall into the surveyor's way to measure them in land; though indeed in broad measure, paving, &c. often.

C H A P. VIII.

Of laying out new lands; very useful for surveyors, in his Majesty's plantations in America.

A certain quantity of acres being given, how to lay out the same in a square figure.

ANNEX to the number of acres given, 5 cyphers, which will turn the acres into links; then from the number thus increased, extract the square root, which shall be the side of the proposed square.

E X A M P L E.

Suppose the number given be 100 acres, which I am to lay out in a square figure; I join to the 100 5 cyphers, and then it is 100,00000 square links; the root of which is 3162 nearest, or 31 chains, 62 links, the length of one side of the square.

Again,

If I were to cut out of a corn-field one square acre, I add to 1 five cyphers, and then is it 100000; the root of which is 3 chains, 16 links, and something more for the side of that acre.

To lay out any given quantity of acres in a right-angled parallelogram, whereof one side is given.

Turn first the acres into links, by adding, as before, five cyphers; that number thus increased divide by the given side, the quotient will be the other side.

E X A M P L E.

It is required to lay out 100 acres in a parellelogram, one side of which shall be 20 chains; first to the 100 acres I add five cyphers, and it is 100,00000; which divide by 20 chains, or 2000 links; the quotient is 50 chains, 0 links, for the other side of the parellelogram.

To lay out any given number of acres in a parallelogram that shall be 4, 5, 6, or 7, &c. times longer than it is broad.

In Carolina, and all lands lying by the sides of rivers, except seigniores or baronies, are (or ought by order of the lords proprietors, to be) thus laid out. To do which, first, as above taught, turn the given quantity of acres into links, by annexing five cyphers: which sum divide by the number given for the proportion between the length and breadth, as 4, 5, 6, 7, &c. the square root of the quotient will shew the shortest side of such a parallelogram.

E X A M P L E.

Admit it were required of me to lay out 100 acres in a parallelogram, that should be five times as long as broad: first to the 100 acres I add five cyphers, and it makes 100,00000; which sum I divide by 5, the quotient is 2000000; the root of which is nearest 14 chains, 14, links; and that, I say, shall be the short side of such a parallelogram; and by multiplying that 14.14 by 5, shews me the longest side thereof to be 70 chains, 70 links.

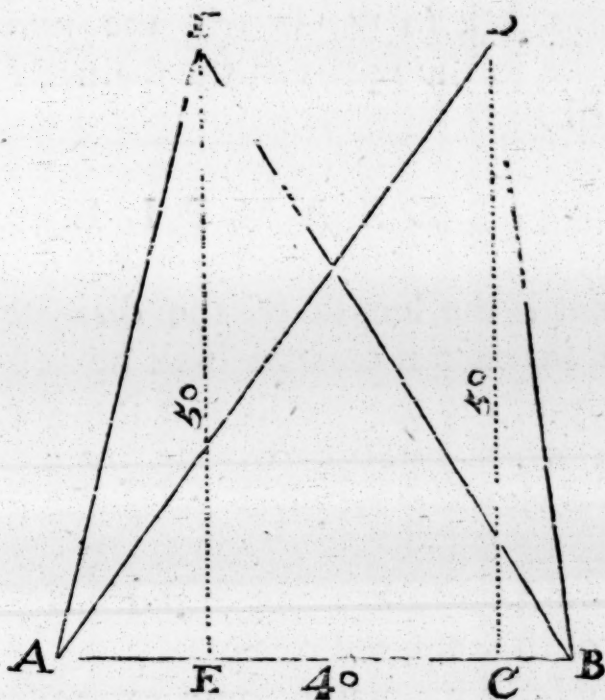
To make a triangle upon a given base, that shall contain any number of acres.

To double the given number of acres, annex five cyphers, and divide by the base, the quotient will be the length of the perpendicular required.

E X A M P L E.

Upon a given base whose length is 40 chains, I am to make a triangle that shall contain 100 acres. First, I double the 100 acres, and annexing five cyphers thereto, it makes 200,00000; which I divide by 40 chains, the given base; the quotient is 50 chains, 0 links, for the height of the perpendicular. As in this figure, A B is the given base 40; on any part of it, as C, I make the perpendicular C D, equal

equal to 50 chains, and I draw the lines D A, D B, which make the triangle D A B, containing just 100 acres, as required. If I had made the perpendicu-



lar E F equal to 50, and drawn the lines F A, F B, I should have made the triangle F A B, containing 100 acres, the same as D A B.

If you consider this well when you are laying out a new piece of land, of any given content, in *America*, or elsewhere, although you meet in your way with many lines and angles; yet you may, by making a triangle to the first station you began at, cut off any quantity required.

To find the length of the diameter of a circle, which shall contain any number of acres required.

Say as 11 is to 14, so will the number of acres given be to the square of the diameter of the circle required.

E X A M P L E.

What is the length of the diameter of a circle, whose superficial content shall be 100 acres? Add five cyphers to the 100, and it makes 100,00000 links; which multiply by 14, *facit* 1400000000; which divided by 11, gives for quotient 12727272; the root of which is 35 chains, 67 links, and better, almost 68 links: and so much shall be the diameter of the required circle.

I might add many more examples of this nature; such as to make ovals, regular polygons, &c. that should contain any assigned quantity of land. But because such things are merely speculative, and seldom or never come in practice, I here omit them.

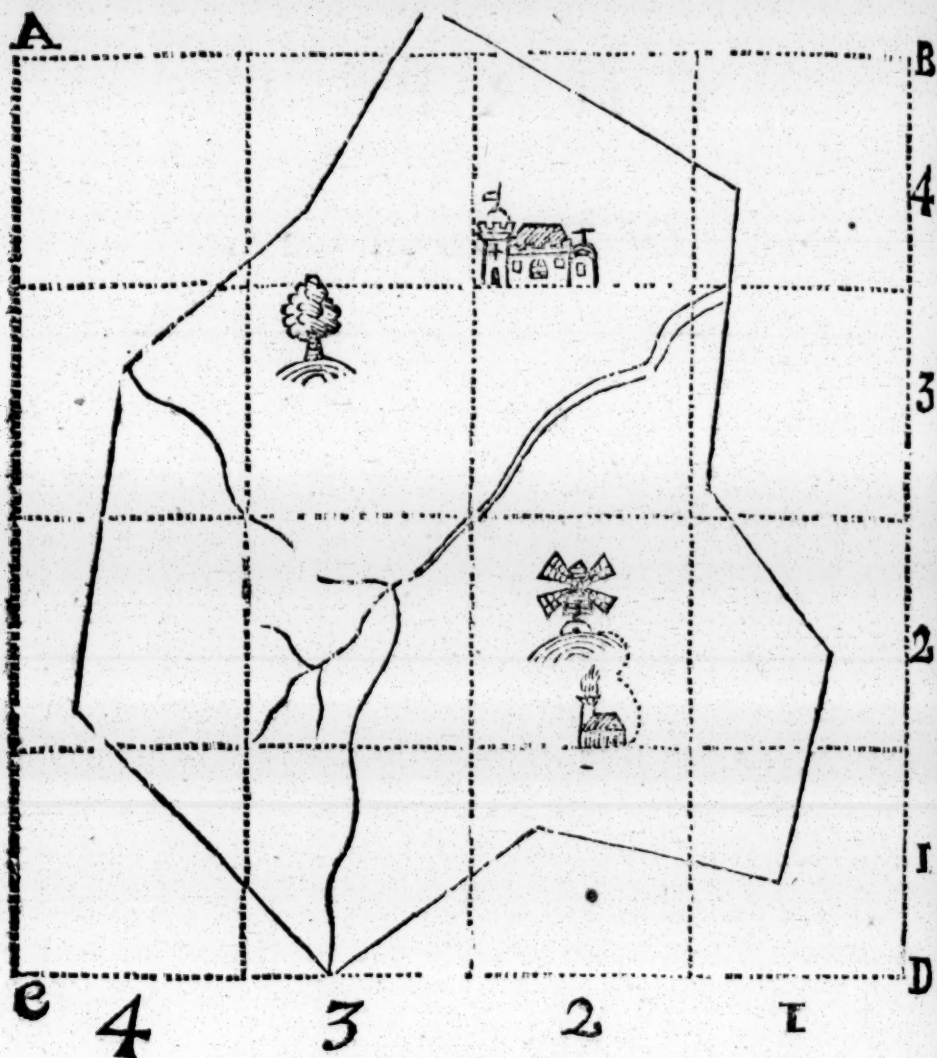
C H A P IX.

Of REDUCTION.

To reduce a large plot of land or map into a less compass, according to any given proportion ; or, è contra, how to enlarge one.

THE best way to do this, is, if your plot be not over large, to plot it over again by a smaller scale : but if it be large, as the map of a county, or the like, the only way is to compass in the plot first with one great square ; and afterwards to divide that into as many little squares as you shall see convenient. Also make the same number of little squares upon a fair piece of paper by a less scale, according to the proportion given. This done, observe in what square, and part of the same square, any thing remarkable happens to be, and accordingly put it down in your lesser squares ; and that you may not mistake, it will be proper to number your squares. I cannot make this plainer than by giving you the following example, where the plot A B C D, made by a scale of 10 chains in an inch, is reduced into the plot E F G H, of 30 chains in an inch.

There



There

There are several other ways taught by surveyors for reducing plots or maps. Mr. Rathborn, and after him Mr. Holwell, adviseth to make use of a scale or ruler, (having a center hole at one end, through which to pin it down on a table, so that it may play freely round) numbered from the center end to the other with lines of equal parts. The use of which is thus: lay down upon a smooth table the map or plot you would reduce, and glew it with mouth glew fast to the table at the four corners thereof. Then take a fair piece of paper, of sufficient bigness to contain your reduced plot, and lay that down upon the other; the middle of the last about the middle of the first. This done, lay the center of your reducing scale near the center of the white paper, and there with a needle through the center make it fast; yet so, that it may play easily round the needle. Then moving your scale to any remarkable thing of the first plot, as an angle, a house, the bend of a river, or the like; see against how many equal parts of the scale it stands, as suppose 100; then taking the $\frac{1}{2}$, the $\frac{1}{4}$, the $\frac{1}{8}$, or any other part thereof, according to the proportion you would have the reduced plot to bear, and make a mark upon the white paper against 50, 25, 33, $\frac{1}{3}$, &c. of the same scale: and thus turning the scale about, you may first reduce all the outermost parts of the plot: which done, you must double or treble, &c. the lines in the lesser plot, in order to reduce the innermost part near the center.

But I advise rather to have a long scale, made with a center hole for fixing it to the table, at the distance of about one third part of the scale, so that $\frac{1}{3}$ of the

the scale may be one way numbered with equal parts from the center hole to the end ; and $\frac{1}{2}$ part thereof numbered the other way to the end, with the same number of equal parts, though less. Upon this scale may be several lines of equal parts, the less to the greater; according to different proportions. Being thus provided with a scale, glew down upon a smooth table your greater plot to be reduced ; and close to it, upon the same table, a paper, about the bigness whereof you would have your smaller plot. Fix with a strong needle the center of your scale, between both ; then turning the longer end of your scale to any remarkable place in your plot ; to be reduced, see what number of equal parts it cuts, as suppose 100 ; there holding fast the scale, against 100 upon the smaller end of your scale make a mark upon the white paper. Proceed thus round all the plot, drawing lines, and putting down all other particulars as you proceed, for fear of confusion through many marks in the end ; and when you have done, although at first the reduced plot will seem to be quite contrary to the other, yet when you have unglewed it from the table, and turned it about, you will find it to be an exact epitome of the first. You may have for this work divers centers made in one scale, with equal parts proceeding from them accordingly ; or you may have several scales, according to the different proportions, which is better.

What has been hitherto said concerning the reducing of a plot from a greater volume to a less, the same is to be understood, *vice versâ*, of enlarging a plot from a less to a greater. But this last seldom comes in practice.

To

To change customary measure into statute and the contrary.

In some parts of *England*, for wood-lands, and in most parts of *Ireland*, for all sorts of lands, they account 18 feet to a perch, and 160 such perches to an acre, which is called *customary measure*: whereas our true measure for land, by *act of parliament*, is but 160 perches for one acre, at 16 feet and an half to the perch. Therefore to reduce the one from the other, the rule is,

As the square of one sort of measure
is to the square of the other:

So is the content of the one
to the content of the other.

Thus, if a field measured by a perch of 18 feet, accounting 160 perches to the acre, contain 100 acres; how many acres shall the same field contain by a perch of 16 feet $\frac{1}{2}$?

Say, If the square of 16 feet $\frac{1}{2}$, viz. 272.25, give the square of 18 feet, viz. 324, What shall 100 acres *customary* give? Answer, 119 $\frac{9}{10}$ of an acre *statute* measure.

Knowing the content of a piece of land, to find what scale it was plotted from.

First, By any scale measure the content of the plot; which done, say:

As the content thus found, is to the square of the scale I tried by;

So is the true content, to the square of the true scale it was plotted by.

Admit

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Admit there is a plot of a piece of land containing 10 acres, and measuring it by a scale of 11 equal parts to an inch, I find it contains 12 acres $\frac{1}{10}$ of an acre: then I say, if 12 $\frac{1}{10}$ give 121 (the square of the number of equal parts in the length of the scale I used) what shall 10 give? Answer, 100, whose square root 10 is the number of equal parts in the length of the scale the plot was protracted by. Therefore if the scale I measured by contained 11 equal parts to an inch, the plot was laid down from a scale of 10 equal parts to an inch.



C H A P. X.

Instructions for surveying a manor, county, or whole country.

To survey a manor, observe the following rules.

1. **W**ALK or ride over the manor once or twice, that you may have, as it were, a map of it in your head; by which means you may the better know where to begin, and proceed on with your work.

2. If you can conveniently survey round the whole manor with your chain and instrument, taking all the angles, and measuring all the lines thereof; taking notice of roads, lanes, or commons, as you cross

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cross them: also minding well the ends of all dividing hedges, where they butt upon your bound-hedges, in this manner.



3. Take a true draught of all the roads and by-lanes in the manor, putting down also the true buttings of all the field-fences to the road. If the road be broad, or goes through some common or waste ground, the best way is to measure, and take the angles on both sides thereof; but if it be a narrow lane, you may only measure along the midst thereof, taking the angles and offsets to the hedges, and measure your distances truly: also if there be any considerable river either bounds or runs through the manor, survey that also truly, as is hereafter taught.

4. Make a true plot upon paper of all the foregoing work, and then will you have a resemblance of the manor, though not compleat; which to make so, go to all the buttings of the hedges, and there survey every field distinctly, plotting it accordingly every night, or rather twice a day, 'till you have perfected the whole manor.

5. When thus you have plotted all the fields, according to the buttings of the hedges found in your first surveys, you will find that you have very nigh, if not quite, done the whole work: but if there be any fields which lie so within others, that they are not bounded on either side by a road, lane, or river, then you must also survey them, and place them in your plot, accordingly as they are bounded by other fields.

6. Draw

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6. Draw a fair draught of the whole, putting down therein the manor-house, and every other considerable house, wind-mill, water-mill, bridge, wood, coppice, cross paths, rills, runs of water, ponds, and any other matters notable therein. Also in the fair draught, let the arms of the lord of the manor be neatly drawn, and a compass in some waste part of the paper; also a scale, the same by which it was plotted. You must also beautify your map with colours and cuts, according as you shall see convenient.

Write down also in every field the true content thereof; and if it be required, the names of the present possessors, and their tenures, by which they hold it of the lord of the manor.

The quality also of the land you may take notice of, as you pass over it, if you have judgment therein, and it be required of you.

To take the draught of a county or country.

1. If the county or country is in any place thereof bounded with the sea, survey first the sea-coast thereof, measuring it all along with the chain, and taking all the angles thereof truly.

2. Which done, and plotted by a large scale, survey next all rocks, sands, or other obstacles that lie at the entrance of every river, harbour, bay, or road upon the coast of that county or country; which plot down accordingly, as shall be shewn farther on.

3. Sur-

3. Survey all the roads, taking notice as you go along, of all towns, villages, great houses, rivers, bridges, mills, cross-ways, &c. Also take the bearing at two stations of such remarks as you see out of the road, or by the side thereof.

4. Also survey all the rivers, taking notice how far they are navigable, what branches run into them, and where they begin; what fords they have, bridges, &c.

5. All this being exactly plotted, will give you a truer map of the country, than any that I know of hath yet been made in *England*. However, you may look upon old maps, and if you find therein any thing worth notice, that you have not yet put down, you may go and survey it; and thus by degrees you may finish a country, so as not to leave out even one gentleman's house; for it will scarcely happen but some very remarkable thing will come into your view, either from the roads, the rivers, or sea coast.

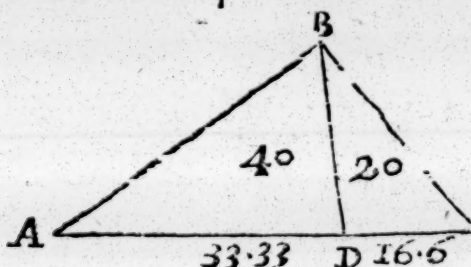
6. Lastly, With a large quadrant take the true latitude of the place, in three or four places of the county; which put down upon the edge of your map accordingly.

C H A P. XI.

Of dividing lands.

To divide a triangle several ways.

Suppose A B C a triangular piece of land, containing 60 acres, to be divided between two men, one to have 40 acres cut off towards A, and the



other 20 acres towards C; and the line of division to proceed from the angle B.

First, measure the base A C, viz. 50 chains;

then say by the Rule of Three, if the whole content 60 acres give 50 chains for its base, what shall 40 acres give? Multiply and divide, the quotient will be 33 chains, 33 links; which set off upon the base from A to D, and draw the line B D, which shall divide the triangle as was required. If it had been required to have divided the same into 3, 4, 5, or more unequal parts in given proportions, you must, as before, by the Rule of Three, have found the length of each several base; much after the same manner as merchants calculate their loss or gain by the rule of Fellowship.

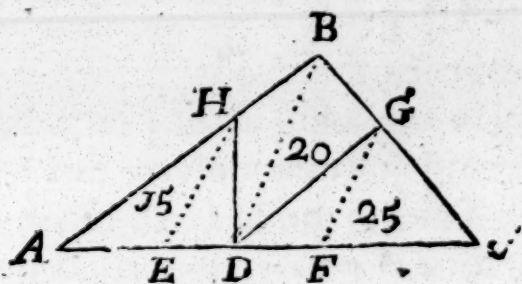
There are several ways of doing this geometrically, without the help of arithmetic; but my business

is

is not so much to shew you what may be done, as how to do it by the most easy and practicable way.

To divide a triangular piece of land into any number of unequal parts, by lines proceeding from any point assigned in any side thereof.

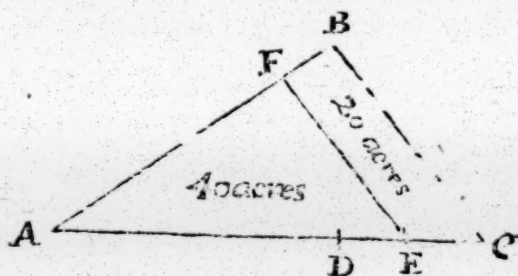
Let A B C, the triangular piece of land, containing 60 acres, be divided between three men, the first to have 15 acres, the second 20, and the third 25 acres, and the lines of division to proceed from D: first, measure the base, which is 50 chains; then divide the base into three parts, as you have been before taught, by saying, if 60 give 50, what shall 15 give? Answer, 12 chains, 50 links for the



first man's base; which set off from A to E. Again, say If 60 give 50, what shall 20 give? Answer, 16 chains, 66 links for the second man's base; which set off from E to F; then consequently the third man's base, viz. from F to C, must be 20 chains, 84 links. This done, draw an obscure line from the point assigned D, to the opposite angle B; and from E and F draw the lines E H, F G parallel to B D. Lastly, From D draw the lines D H, D G, which shall divide the triangle into three such parts as were required.

To divide a triangular piece of land, according to any proportion given by a line parallel to one of the sides.

A B C is the triangular piece of land, containing 60 acres, the base A C is 50 chains. This piece of



land is to be divided between two men, by a line parallel to B C, in such proportion that the one have 40 acres, the other 20.

First, Divide the base, as has been before taught, and let the point of division fall in D, A D being 33 chains, 33 links; and D C 16 chains, 67 links.

Secondly, Find a mean proportion between A D and A C; by multiplying the whole base 50 by A D 33, 33, the product is 1666.5000; of which the square root being extracted, gives 40 chains, 82 links; set this off from A to E. Lastly, From E draw E F parallel to B C, which divides the triangle as demanded.

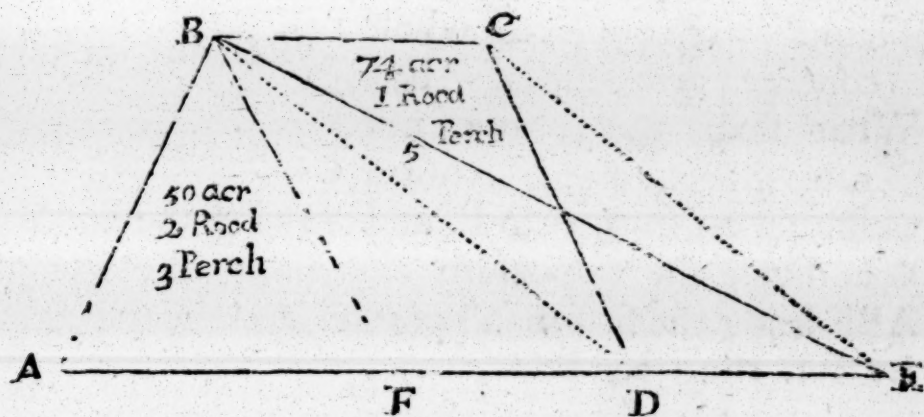
Of dividing four-sided figures or trapezia.

Before I begin to teach you how to divide pieces of land of four sides, it is convenient first to shew you how to change any four-sided figure into a triangle;

angle; which done, the work will be the same as in dividing triangles.

To reduce a trapezium into a triangle, by lines drawn from any angle thereof.

Let A B C D be the trapezium to be reduced into a triangle, and B the angle assigned: draw the



obscure line B D, and from C make a line parallel thereto, as C E; extend also the base A D, 'till it meet C E in E: then draw the line B E, which shall make the triangle B A E equal to the trapezium A B C D.

Now to divide this trapezium according to any assigned proportion, is no more than to divide the triangle A B E, as before taught; which will also divide the trapezium.

E X A M P L E.

Suppose the trapezium A B C D, containing 124 acres, 3 roods, and 8 perches, is to be divided between

L 3

tween

tween two men, the first to have 50 acres, 2 roods, and 3 perches; the other 74 acres, 1 rood, and 5 perches, and the line of division to proceed from B.

First, Reduce all the acres and roods into perches, then will the content of the trapezium be 19968 perches; the first man's share 8083 perches, the second 11885.

Secondly, Measure the base of the triangle, *viz.* A E 78 chains, 00 links:

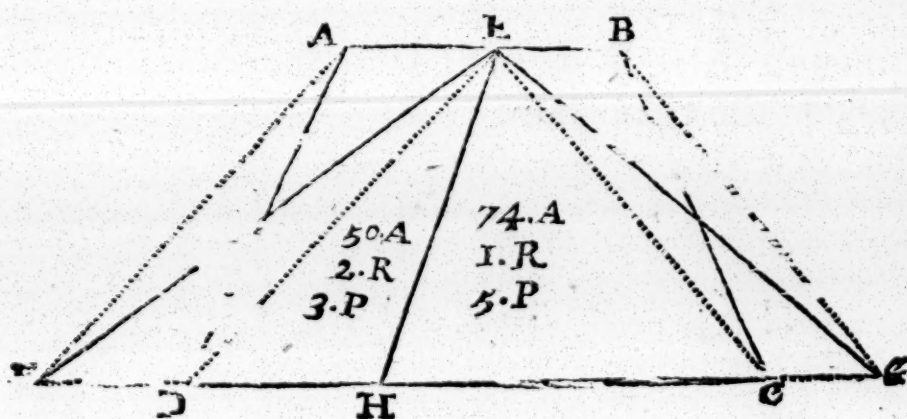
Then say, If 19968 the whole } content give for it's base } 78 chains, 00 links,

What shall 8083, the first } man's part, give? Answer } 31 chains, 52 links:

which set off from A to F, and drawing the line F B you divide the trapezium as desired; the triangle ABF being the first man's portion, and the trapezium BCFD the second's.

How to reduce a trapezium into a triangle, by lines drawn from a point assigned in any side thereof.

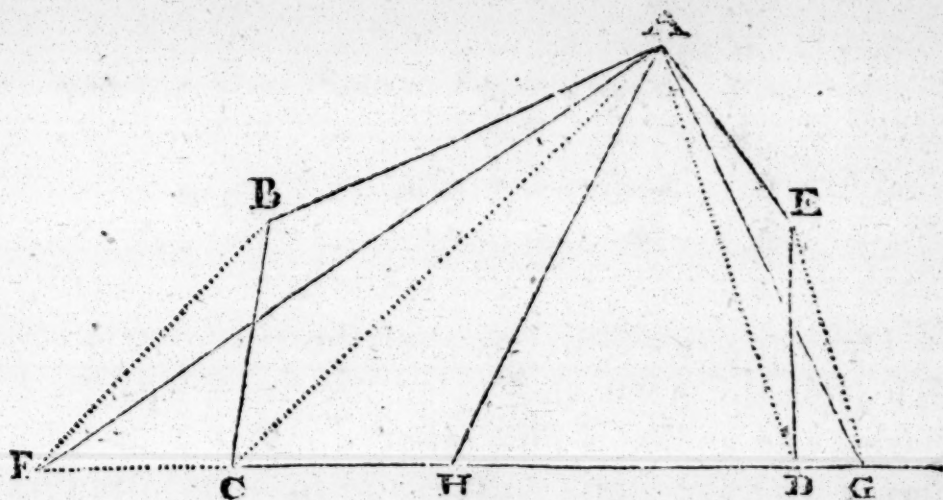
A B C D A the trapezium, E the point assigned, from whence to reduce it into a triangle, and run the division line. The trapezium is of the same con-



tent as the former, viz. 19968 perches; and it is to be divided as before, viz. one man to have 8083 perches, and the other 11885. First, For to reduce it into a triangle, draw the lines ED, EC, and from A and B make lines parallel to them, as AF, BG; then draw the lines EG, EF, and the triangle EFG will be equal to the trapezium ABCDA, which is to be divided as before; therefore find, by the rule of proportion, what the first man's base must be, viz. 31 chains, 52 links, set it from F to H, and draw the line HE; so shall you divide the trapezium according to the former proportion.

To reduce an irregular five-sided figure into a triangle, and to divide the same into any given proportion.

Let ABCDEA be the five-sided-figure; to reduce this into a triangle, first draw the lines AC,

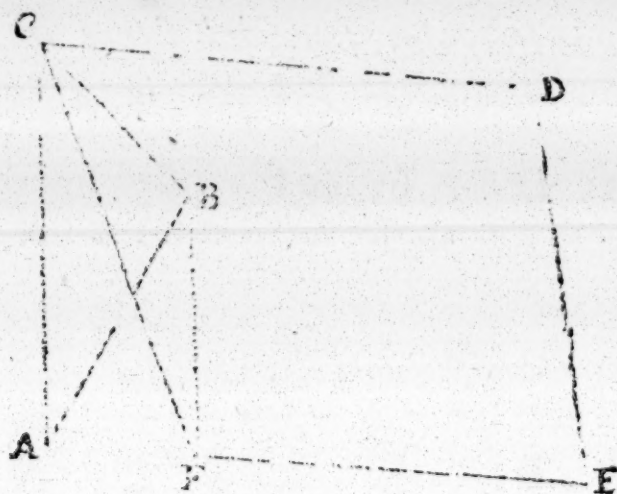


AD; and parallel thereto BF, EG, extending the base from C to F, and from D to G; then draw the lines AF, AG, which will make the triangle AFG equal to the five-sided figure. If this were

to be divided into two equal parts, you must take FH equal to half of the base of the triangle; and from H draw the line HA , which divides the figure $ABCDE$ into two equal parts.

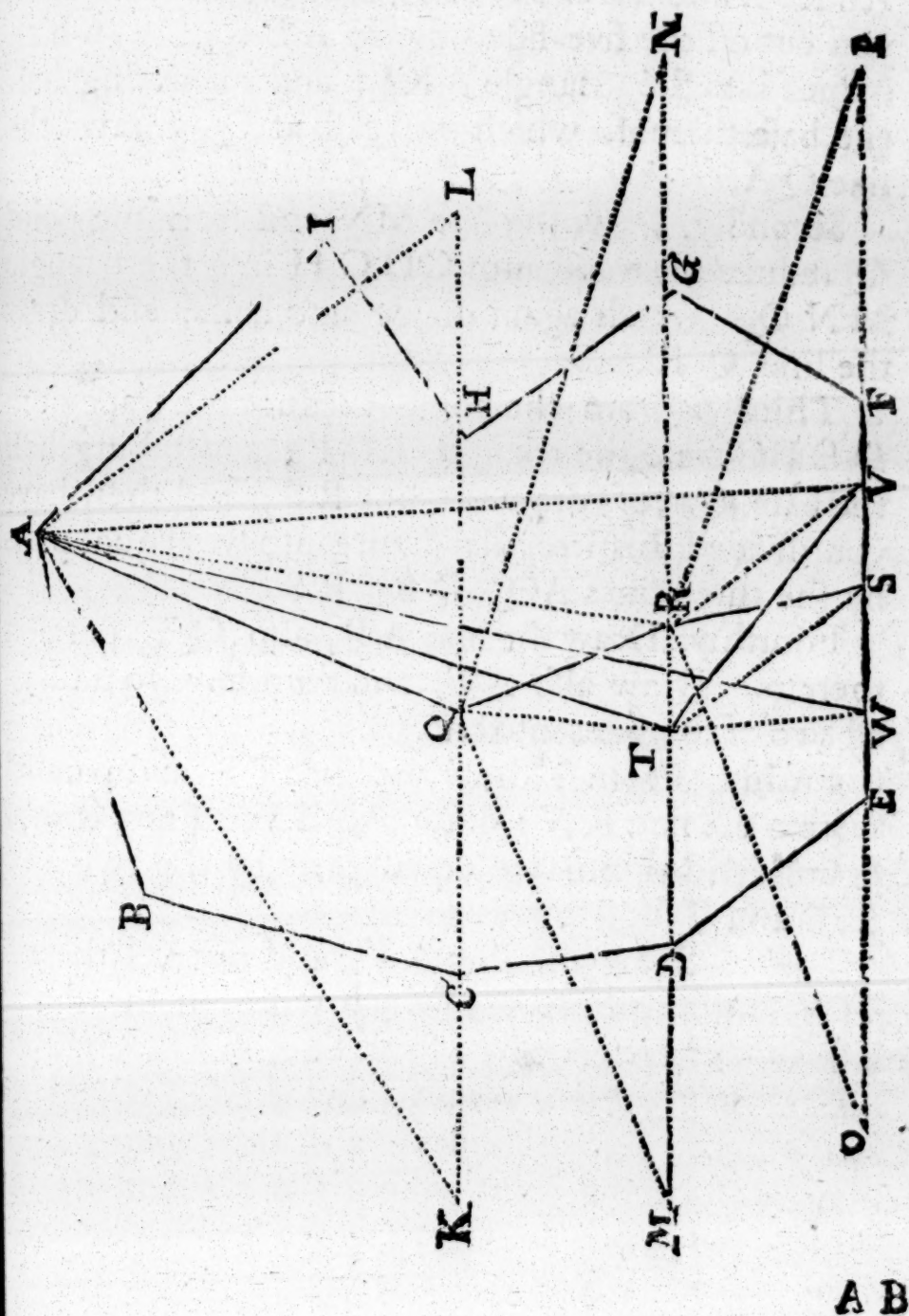
If in dividing the plot of a field, there be outward angles, you may change them after the following manner.

Suppose $ABCDEA$ be the plot of a field, and B the outward angle.



Draw the line CA ; parallel thereunto draw also BF ; join the points C, F , and the five-sided figure, having one angle, is now reduced into a four-sided figure, or trapezium; which you may again reduce into a triangle, as has been before taught.

To divide an irregular plot of any number of sides, according to any given proportion, by a strait line drawn through it.



ABCDEFGHI A is a field to be divided equally between two men, by a strait line proceeding from *A*.

First, Consider how to divide the field into five-sided figures and trapezia, that you may the better reduce it into triangles: as by drawing the line *KL*, you cut off the five-sided figure *ABCHI*; which reduce into the triangle *AKL*, and measuring half the base thereof, which will fall at *Q*, draw the line *QA*,

Secondly, Draw the line *MN*, and from the point *Q* reduce the trapezium *CDGH* into the triangle *MNQ*; which again divide into halves, and draw the line *QR*.

Thirdly, From the point *R* reduce the trapezium *DEFG*, into the triangle *ROP*; and taking half the base thereof, draw the line *RS*; and then have you divided this irregular figure into two equal parts by the three lines *AQ*, *QR*, *RS*.

Fourthly, Draw the line *AR*, also *QT* parallel thereto. Draw also *AT*, and then have you turned two of the lines into one.

Fifthly, From *T* draw the lines *TS*, and parallel thereto the line *RV*: draw also *TV*. Then is your figure divided into two equal parts by the two lines *AT* and *TV*.

Lastly, Draw the line *AV*, and parallel thereto *TW*. Draw also *AW*, which will cut the figure into two equal parts by a strait line, as was required.

You may, if you please, divide the whole of such a figure into triangles; and then divide each triangle from the point where the division of the last fell, and then will your figure be divided by a crooked line, which you may bring into a strait one, as above.

The

The above is a good way of dividing lands ; but surveyors seldom take so much pains about it ; I shall therefore shew you how they commonly abbreviate their work, as is indeed

An easy way of dividing lands.

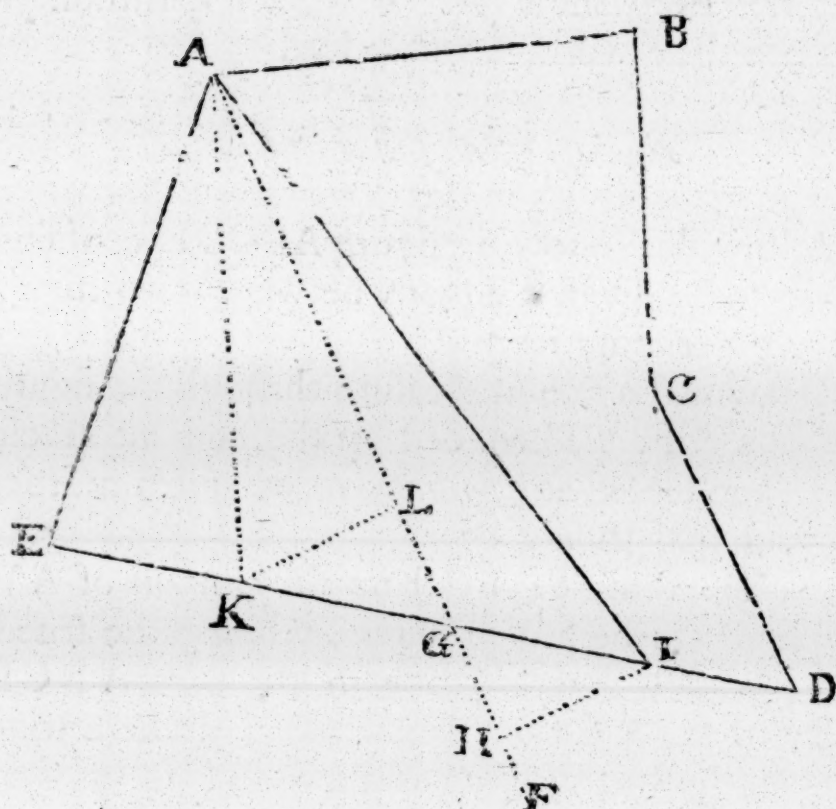
Admit the following figure ABCDE contains 46 acres, to be divided equally between two men, by a line proceeding from A.

Draw first a line at pleasure through the figure, as the line A F. Then cast up the content of either part, and see what it wants, or what it is more than the true half should be.

As for example ; I cast up the content of A E G, and find it to be but 15 acres ; whereas the true half is 23 acres ; 8 acres being in the part A B C D G more than A E G. Therefore I make a triangle containing 8 acres, and add it to A E G, as the triangle A G ; then the line A I parts the figure into two equal quantities.

But more plainly how to make this triangle : measure first the line A G, which is 23 chains 60 links. Double the 8 acres, they make 16 ; to which add five cyphers to turn them into chains and links, and then they make 1600000 ; which divide by A G 2360, the quotient is 6 chains 77 link ; for the perpendicular H I, take from your scale 6 chains, 77 links, and set it so from the base A G, that the end of the perpendicular may just touch the line E D, which suppose at I. Then draw the line A I, which makes the triangle A C I just 8 acres, and divides the whole figure as desired.

If



If it had been required to have set off the perpendicular the other way, you must still have made the end of it but just touch the line ED, as L K does : for the triangle A K G is equal to the triangle A G I, each 8 acres.

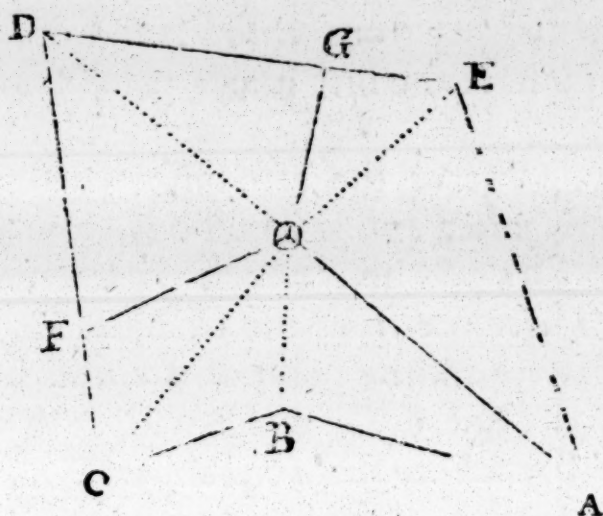
And thus you may divide any piece of land of any number of sides, according to any proportion, by strait lines through it with equal certainty, and more ease than the former way.

Note, You might also have drawn the line A D, and measured the triangle A G D, and afterwards have divided the base G D in I, according to the given

given proportion ; this will appear plainer by the following example :

Suppose a field containing 27 acres, is to be divided between three men, each to have 9 acres, and the lines of division to run from a pond in the field so that each person may have the benefit of the water, without going over another's land.

First, From the pond $\odot$ draw lines to every angle, as $\odot A$, $\odot B$, $\odot C$, $\odot D$, $\odot E$; and then



is the figure divided into five triangles; measure each of these, and put their contents down severally, which reduce into perches, and you will have the

Triangle	{	A $\odot$ B	}	be	{	674	}	Perches.
		B $\odot$ C				390		
		C $\odot$ D				1238		
		D $\odot$ E				911		
		E $\odot$ A				1107		

The whole content is 4320 perches, or 27 acres, and each man's proportional part 1440 perches.
From

From $\odot$ to any angle draw a line for the first division-line, as $\odot A$, then consider that the first triangle $A \odot B$ is but 674 perches, and the second $B \odot C$ 390, both together but 1064 perches, less by 376 than 1440, one man's portion. You must therefore cut off from the third triangle $C \odot D$ 376 perches for the first man's dividing line; which you may do thus: the base DC is 18 chains, the content of the triangle 1238 perches: say then, if 1238 perches give the base 18 chains 00 links; What shall 376 perches give? Answer 5 chains, 45 links; which set from C to F , and drawing the line $\odot F$ you have the first man's part, *viz.* $A \odot FCB A$.

Secondly, Observe the remaining part of the triangle $C \odot D$, after 376 is taken out, and you will find it to be 861 perches, which is less than 1440 by 578. Therefore from the triangle $D \odot E$ cut off 578 perches, and the point of division will fall in G . Draw the line $\odot G$, which with $\odot A$ and $\odot F$, divides the figure into three equal parts.

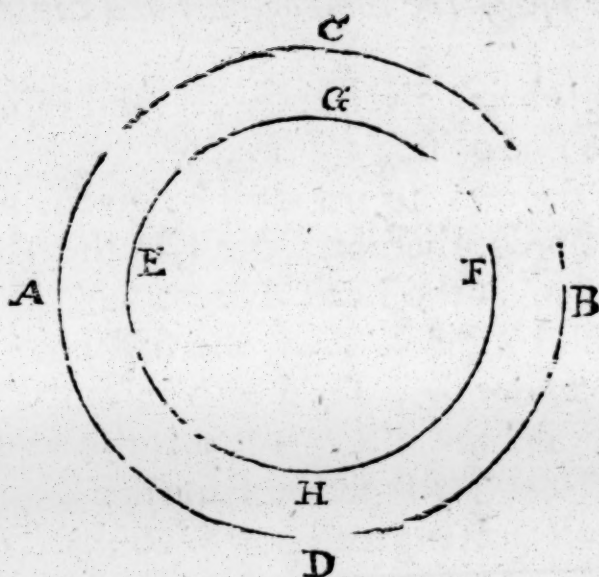
To divide a circle according to any proportion, by a line concentric with the first.

The areas of circles are in proportion to one another as the squares of their semi-diameters; therefore, if you divide the square of the semi-diameter by the proportion given, and extract the square root, you will have your desire.

EXAMPLE.

$ABCD$ be a circle to be equally divided between two men.

The



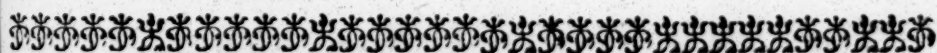
The diameter thereof is 2 chains.

The semidiameter 1 chain, or 100 links.

The square thereof 10000.

Half the square 5000.

The root of the half 71 links ; which take from your scale, and upon the same center describe the circle GEHF, which will divide the circle ABCD into two equal parts.



C H A P XII.

Trigonometry : or, *The mensuration of right-lined triangles.*

THE use of the table of logarithm numbers I have shewed in *chap. I.* concerning the extraction of the square root. Here follows
The

The use of the table of sines and tangents.

Any angle being given in degrees and minutes, how to find the sine or tangent thereof.

Let 27 degrees, 10 minutes be given, to find the sine and tangent thereof. First, in the table of sines and tangents, at the head thereof seek for 27; and having found it, look down the first column on the left-hand under M, for the 10 minutes, and right against it under the title *Sin.* stands the sine required, viz. 9,659517; also in the same line under the title *Tang.* stands the tangent of $27^{\circ}. 10'$, viz. 9,710282: but if the degrees exceed 45, then look at the foot of the tables for the degrees, and upon the right-hand column for the minutes; and right against it you will find the sine and tangent above the title *Sine. Tan.* Thus the sine of 64 degrees 50 minutes, is 9,956684; the tangent thereof is 10.328037.

To find the co-sine, or sine complement; the co-tangent, or tangent complement of any given number of degrees and minutes.

The co-sine, or co-tangent, of an angle is the sine and tangent of the remaining degrees and minutes, after subtracting it from 90; thus, take 25 degrees 10 minutes from 90 degrees, 00 min. there remains 64 degrees, 50 minutes; the sine of which is, as before, 9,956684: and that it is also the sine complement of 25 degrees, 10 minutes.

But a more ready way to find the co-sine, or co-tangent of any number of degrees given, is to look for the degrees and minutes as before taught, for sines and tangents; and right against it under titles co sine and co-tangent; or above, if the degrees exceed 45, you will find the co-sine or co-tangent required: thus the co-sine of 30 degrees, 15 minutes, is 9,936431. the co-tangent of 58 degrees, 10 minutes is 9,792974.

A sine or tangent, co-sine or co-tangent being given, to find the degrees and minutes belonging thereto.

This is the converse of the former; for you must seek in the tables for the sine, &c. given, or the highest that can be found thereto, and right against it you will find the *minutes* and *degrees* over-head. Let the sine 8,742259 be given, right against it stands 3 degrees, 10 minutes.

Remember that multiplication is performed with these logarithmic tables by addition, and division by subtraction. If I were to multiply 5 by 4, first I look for the logarithm of 5, which is 0,698970
The logarithm of 4 is 0,602060

Added together, they make

1,301030

which 1,301030 I seek for in the table of logarithms; and right against, under title *num.* stands 20, the product of 5 multiplied by 4.

M

If

If I were to divide 20 by 5, first I look for the logarithm of 20, which, as above, is
the logarithm of 5 is

1,30,030
0,698970

After subtraction remains

0,602060

and the number answering to this logarithm you will find to be 4.

And thus by addition and subtraction the rule of three is performed with the logarithms, viz. by adding the second and third terms together, and from their sum subtracting the first.

E X A M P L E.

If 15 give 32, what will 45 give?
The logarithm of 15 is

1,176091

The logarithm of 45 is

1,653212

The logarithm of 32 is

1,505150

The two last added together make

3,158362

From that sum I subtract the first term }
and there remains — — — }

1,982271

Against 1,982271 in the table I find the number 96. I answer therefore, If 15 gives 32, 45 will give 96.

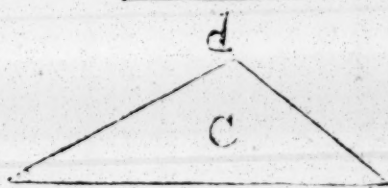
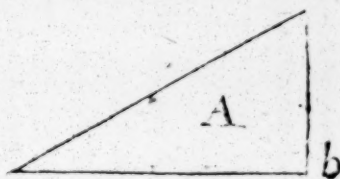
This you must observe to do in the following cases of triangles, always to add the second and third numbers together, and from their product to subtract the first, the remainder will be the the logarithm number, sine, or tangent of your required side or angle.

Certain

Certain theorems for the better understanding right lined triangles.

1. A right-lined triangle is a figure comprehend-
ed within three strait lines.

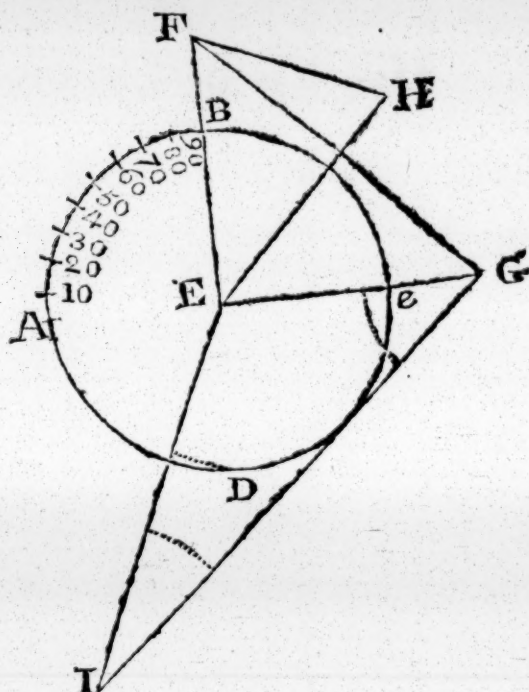
2. It is either right-an-
gled as A, having one right
angle, which contains just
90 degree, viz. that at *b* ;
or else oblique as B, which
consists of three acute an-
gles, neither of them so
great as 90 degrees ; or
as C, which consists of two
acute angles and one ob-
tuse, viz. that at *d*.



3. All the three angles
of any triangle are equal
to two right angles, or 180 degrees ; so that one
angle being known, the sum of the other two becomes
known also ; or two being known, the third may be
found by subtracting the two known angles out
of 180 degrees ; the remainder is the third angle.

To understand well what the quantity of an angle
is, take this following illustration.

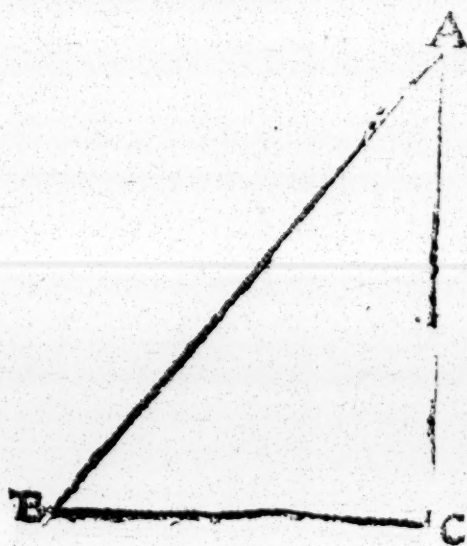
Let A B C D be a circle, whose circumference is
divided (as all circles are supposed to be) into 360
equal parts called degrees, and each of these again
divided into 60 equal parts, which are called minutes:
now a right-angled triangle is that which cuts off one



fourth part of this circle, *viz.* 90 degrees such is the triangle F E G.

An angle cut off being less than 90 degrees, is acute as the angles H E F.

The angle G E I is obtuse because the two lines that proceed from E, take in betwixt them more than a quarter of the circle.



5. Every

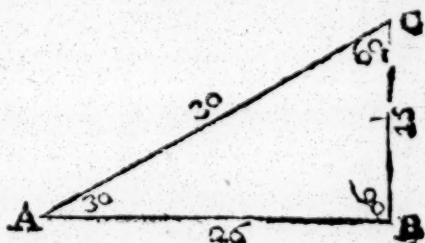
5. Every triangle hath six parts, *viz.* three sides and three angles ; the sides are sometimes called legs ; but most commonly in right angled triangles the bottom line, as BC, is called the base, then is AC, the perpendicular ; but the longest line A B is always called the hypothenufe. The sides are proportional to the fines of their opposite angles ; so that any three parts of the six being known, (except the three angles) the rest may easily be found.

6. When an angle exceeds 90 degrees, subtract it out of 180, and work by the remainder, which is called the supplement thereof.

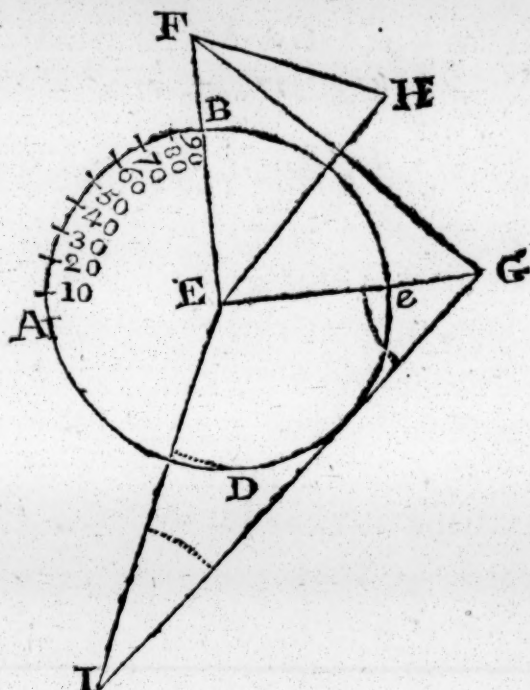
C A S E I.

In a right-angled triangle, the base being given, and the acute angle at the base ; to find the hypothenufe and perpendicular.

In a right-angled triangle A B C, there is given the base A B, 26 equal parts, as yards, perches, &c. and the angle at A 30 degrees ; to find the length of the hypothenufe A C ;



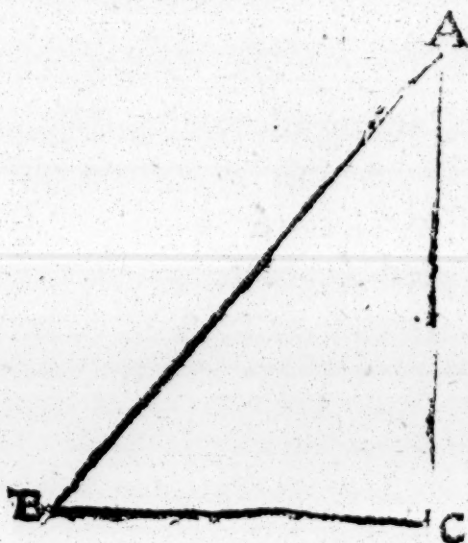
As the sine complement of the angle at A
 is to the logarithm of the base 26,
 So is the radius or sine of 90°
 to the logarithm of the hypothenufe A C equal
 30.



fourth part of this circle, *viz.* 90 degrees such is the triangle F E G.

An angle cut off being less than 90 degrees, is acute as the angles H E F.

The angle GEI is obtuse because the two lines that proceed from E, take in betwixt them more than a quarter of the circle.



5. Every

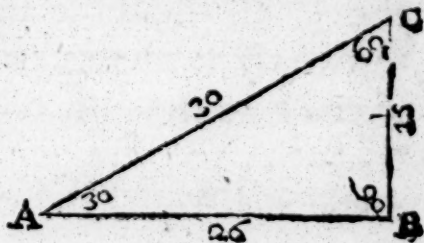
5. Every triangle hath six parts, *viz.* three sides and three angles ; the sides are sometimes called legs ; but most commonly in right angled triangles the bottom line, as BC, is called the base, then is AC, the perpendicular ; but the longest line A B is always called the hypotenuse. The sides are proportional to the sines of their opposite angles ; so that any three parts of the six being known, (except the three angles) the rest may easily be found.

6. When an angle exceeds 90 degrees, subtract it out of 180, and work by the remainder, which is called the supplement thereof.

C A S E I.

In a right-angled triangle, the base being given, and the acute angle at the base ; to find the hypotenuse and perpendicular.

In a right-angled triangle A B C, there is given the base A B, 26 equal parts, as yards, perches, &c. and the angle at A 30 degrees ; to find the length of the hypotenuse A C ;



As the sine complement of the angle at A
 is to the logarithm of the base 26,
 So is the radius or sine of 90°
 to the logarithm of the hypotenuse A C equal
 30.

The sine complement of 30 degrees is	9,937531
The logarithm of 26 is	1,414973
The radius, or sine of 90°	10,000000
The two last added together	<u>11,414973</u>
Remains, after subtracting the first numb.	<u>1,477442</u>

Which if you look for in your table of logarithms, you will find the nearest number answering thereto to be 30, the length of the hypotenuse required.

Note in your table, when you cannot find exactly the logarithm you look for, you must take the nearest thereto; as in this example, I find 1,477121 to be the nearest to 1,477442. Note also, that the sine complement of the angle at A, is the right sine of that at C. For the angle at A in a right-angled triangle being given, you may, by subtraction, easily find the angle at C; because by the rule above, all the three angles of a triangle are equal to two right angles, or 180 degrees; consequently, if you take the sum of the right angle at B 90°, and that at A 30° out of 180°, there will remain the angle at C equal to 60°. But to pursue our question,

To find the perpendicular.

As the sine of the angle A C B 60°
 is to the log. of the base A B 26;
 So is the sine of the angle C A B 30°
 to the log. of the perpendicular C B 15.

Note,

Note, When three letters are put to express an angle, the middle letter denotes the angular point.

The sine of 63 degr. is 9,937531

The log of the base A B 26 is 1,414973

The sine of 30 degr. is 9,698970

The sum or the two last 11,113943

From which subtract the first, remains 1,176412

The nearest number answering to which is 15, equal to the length of the perpendicular line C B.

Otherwise; the hypotenuse A C equal to 30 being first found, you may find the perpendicular thus,

As the sine of the right-an. C B A or rad. 10,000000

is to the log. of the hypoth. A C 30 1,477121

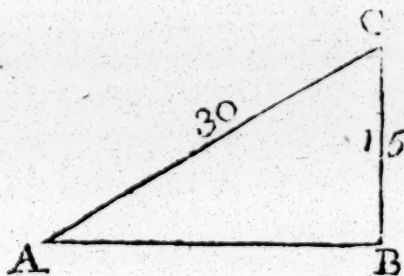
So is the sine of the angle C A B 30 deg. 9,698970

to the log. of the perpendicular 15, 11,176091

C A S E II.

The perpendicular and acute angle A C B being given to find the base and hypotenuse.

Let the perpendicular C B be 15, as before, the angle A C B 60 deg. to find the base.



As the cosine of the angle A C B

is to the logarithm of the perpendicular B C 15;

So is the sine of the angle A C B

to the logarithm of the base A B 26.

The cosine of the angle A C B 60° , is 9,698970

The logarithm of CB 15 is 1,176091

The sine of the angle A C B 60° is 9,937531

11,113622

The nearest log. answering to 26, is

1,414652

For the hypotenuse.

As the sine complement of the angle A C B 60°

is to the log. of the perpendicular C B 15,

So is the sine of the angle A B C, or 90° ,

to the log. of the hypotenuse 30° .

The co-sine of the angle A C B is 9,698970

The log of the perpend. CB 15 is 1,176091

The radius 10,000000

The log. of the hypotenuse 30° 1,477121

Or, the base being first found, find the hypotenuse thus.

As the sine of the angle A C B 60° 9,937531

is to the log. of the base 26 1,414973

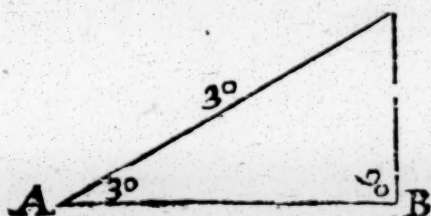
So is the radius 10,000000

to the log. of the hypotenuse (30°) 1,487442

C A S E

C A S E III.

The hypotenuse, and one of the acute angles given, to find the base and perpendicular.



Let the hypotenuse be AC 30;
The angle CAB 30° .

To find the base AB, work thus:

As radius or the sine of the right angle	}	10,000000
CBA 90° .		
is to the log. of the hypoth. AC 30		1,477121
So is the co-sine of the angle CAB 30°		9,937531
to the log. of the base AB (26)		11,414652

To find the perpendicular BC, work thus:

As radius or the sine of the right angle	}	10,000000
CBA 90°		
is to the log. of the hypoth. AC 30		1,477121
So is the sine of the angle CAB 30°		9,698970
to the log of the perpend. (15)		11,176091

Or,

Or the base being first found, find the perpendicular thus :

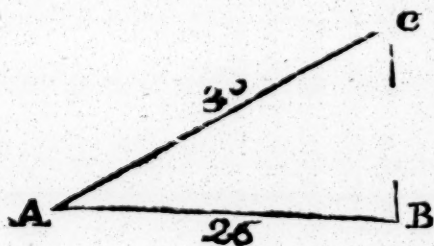
As the co-sine of the angle CAB 30°	9.937531
is to the log. of the base AB 26	1.414973
So is the sine of the angle CAB (30°)	9.698970
	11.113943

to the nearest log. of the perpend. (15) 1.176412

C A S E IV.

The hypotenuse and base being given, to find the acute angles ACB and CAB.

Let AC, the hypotenuse, be 30 equal parts
AB the base 26 ; required the angle ACB,



As the logarithm of the hypotenuse AC 30,
is to the radius, or the sine of the angle CBA 90° ;
So is the logarithm of the base AB 26,
to the sine of the angle ACB 60° .

The

The Operation.

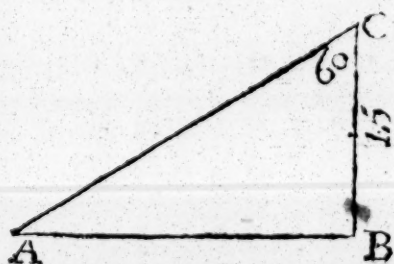
The log. of the hypotenuse A C 30 is	1,477121
The radius	10,000000
The logarithm of the base A B 26	1,414973
The sine of A C B the angle required 60°	9,937852

For the Angle C A B, work thus :

As the log. of the hypotenuse A C 30	1,477121
is to the radius or sine of 90°	10,000000
So is the logarithm of the base A B 26	1,414973
to the co-sine of the angle required 30°	9,937852

C A S E V.

The hypotenuse and perpendicular being given, to find the acute angles, and also the base.



The hypotenuse is 30.
The perpendicular 15.
A B C a right angle.

To

To find the angle at A, work thus :

As the log. of the hypotenuse A C 30	1,477121
to the radius	10,000000
So is the log. of the perpendicular C B 15	1,176091
to the sine of the angle at A 30°	9,698970

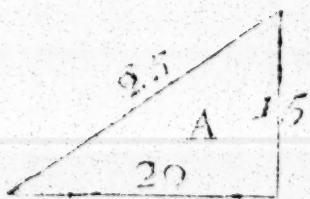
To find the angle at C, work thus :

As the logarithm of the hypotenuse A C 30
is to the radius or sine of 90°.
So is the logarithm of the perpendicular B C 15
to the co-sine of the angle A, or the right sine of
the angle C 60°.

To find the base, work as you were taught in
Case 2.

Here note, that any two sides of a right angled
triangle being given, the third side may be found by
extraction of the square root.

E X A M P L E.



In the right-angled triangle
A, let the given base be 20, the
perpendicular 15, and the hy-
pothenuse required.

The square of the base 20, or
20 multiplied by itself, is 400 : square also the per-
pendicular 15, it gives 225 ; add these squares toge-
ther, and we have 625 ; the square root of

this sum viz. 20 is the length of the hypotenuse; but if the hypotenuse and either of the other sides be given to find the third, you must subtract the less square out of the greater, and the square root of the remainder is the side required. As for example; suppose the hypotenuse 25 and the base 20, to find the perpendicular multiply the hypotenuse by itself, the product is
 multiply the base by itself, it makes

$$\begin{array}{r} 20 \\ 625(25 \\ 45 \end{array}$$

$$\begin{array}{r} 625 \\ 400 \\ \hline \end{array}$$

Subtract 400 from 625, there remains

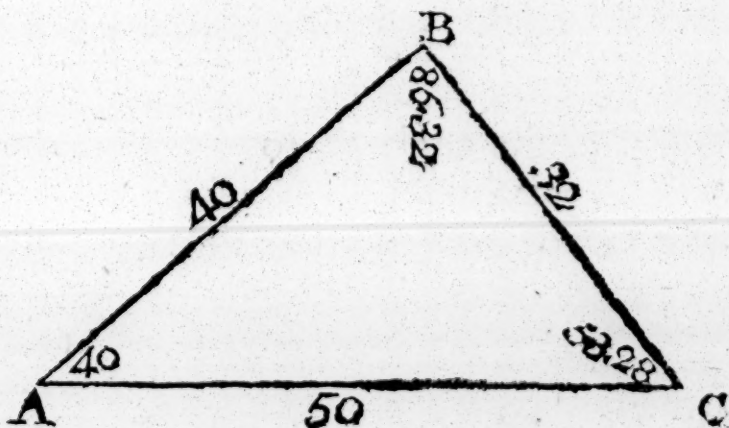
$$\begin{array}{r} 225 \\ \hline \end{array}$$

The root of which is 15, the perpendicular requir'd.

C A S E VI.

Of oblique-angled plane triangles.

Two sides of an oblique triangle being given, and an angle opposite to either of the sides, to find the other angles and also the third side.



In

In the triangle A B C there is given the side A B 40,
the side B C 32 ;

The angle at A 40 degrees,

Required the angle at C.

Note, that in all oblique triangles the sides are in such proportion one to another, as the sines of their opposite angles.

As the logarithm of the side B C 32	1,505150
is to the sine of the angle A 40	9,808067
So is the logarithm of the side A B 40	1,602060
	11,410127

To the sine of the angle at C $53^{\circ}.28'$:	9,904977

To find the angle at B.

Add the two known angles together, viz. that at A 40, and that at C 53.28 , and they make 93 degrees, 28 minutes ; which subtracted from 180 degrees, leaves 86 degrees, 32 minutes, for the angle at B.

Lastly, to find the line A C, say,

As the sine of the angle A 40	9,808067
is to the logarithm of the side B C 32	1,505150
So is the sine of the angle $86^{\circ} : 32$	9,999204
	11,504354

to the log. of the side A C required 50	1,696287

Note,

Note, the nearest whole number answering to the logarithm 1.696287 is 50; but if you admit fractions, the length of the line A C will be only $49\frac{69}{100}$.

C A S E VII.

Two angles being given, and a side opposite to one of them, to find the other opposite side.

In the foregoing triangle there is given the angle A 40 degrees, the angle C 53 degrees, 28 minutes; and the side A B 40, to find the side B C.

As the sine of the angle C 53 : 28
is to the log. of the side A B 40
So is the sine of the angle A 40

9,904992
1,602060
9,808067

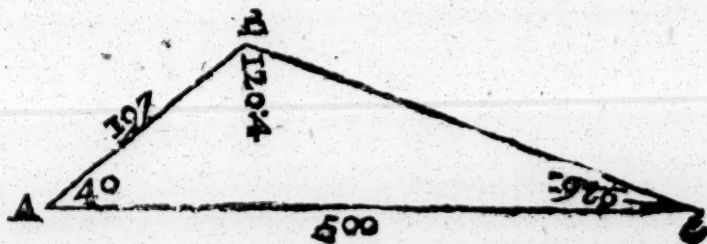
11,410127

to the log. of the side BC, 32 nearly

1,505135

C A S E VIII.

Two sides and the contained angle of a triangle being given to find either of the other angles.



In

In the triangle A B C

there is given the side A B 197,

The side A C 500,

The angle at A 40°

To find either of the other angles

As the log. of the sum of the two sides 627 2,843233

is to the log of their difference 303 2,481443

So is the tang. of the half sum of the } 10,438934
two opposite angles 70° degrees

12,920377

to the tangent of half their difference 50°

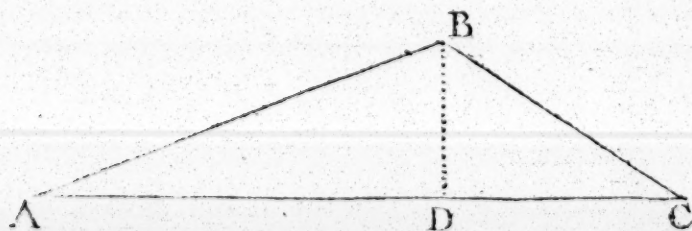
degr. 4 min.

10,077144

Which $50^{\circ} 4'$. added to the half sum of the two unknown angles, viz. 70° gives $120^{\circ} 4'$. for the quantity of the angle at B; but taken from 70° , leaves $19^{\circ} 56'$. the angle at C.

C A S E IX.

The sides of an oblique triangle being given, to find the angles.



You must divide your oblique triangle into two right-angled triangles, thus:

In

Trigonometry.

177

In the triangle A B C

The side A C is 50

The side A B 36

The side B C 20

The sum of the two sides A B, B C 56

Their difference 16

As the log. of the side A C 50 1,698970

is to the log. of the sum of the }
other two sides 56 1,748188

So is their diff. 16 1,204120

2,952308

o the log. of a fourth number 18 1,253338

Subtract this 18 out of the greatest side A C 50, and there remains 32 ; the half of which *viz.* 16, is the base of the right-angled triangle B D C, and the remainder of the line A C, *viz.* A D 34, is the base of the remaining right-angled triangle, B D A.

Now in each of these right-angled triangles, having the base and hypotenuse given, you may find the angles ; by *Case IV.*

Note, It is easier to find the 4th number, for dividing an oblique angled triangle into two right-angled triangles by vulgar arithmetic, than by the tables of logarithms, thus :

N

Square

Square the three given sides, add the two greater squares together, and from that sum subtract the lesser; half the remainder divide by the greater side, the quotient will be the base of the greater right-angled triangle.

E X A M P L E.

In the foregoing triangle, the square of the greatest side AC 50, is

2500

The square of the side AB 36, is

1296

Added together, make

3796

From which subtract the square of the }
least side

400

Remains

3396

The half

1698

Which 1698 divide by 50 the longest side, the quotient is $33\frac{2}{50}$, the base of the greater right-angled triangle, viz. AD; and that being subtracted from 50, leaves $16\frac{2}{50}$ for the base DC of the lesser right-angled triangle.

C A S E

C A S E X.

The three sides of an oblique triangle being given, how to find the superficial content, without knowing the perpendicular.

From half the sum of the three sides subtract each particular side. Add the logarithms of the three differences, also the logarithm of half the sum of the three sides together. Half the total is the logarithm of the content required.

In the foregoing triangle, the sides are 50, 36, 20, their sum is 106 ; the half sum 53.

The differences between the half sum and each particular side, are

	3	log. 0.477121
	17	1.230449
	33	1.518514
The half sum	53	1.724276
Total added		4 950360
The half		2.475180

The number answering to that log. is 298, which is the content of the triangle required.

By vulgar arithmetic thus :

Multiply the first difference by the second, that product by the third, that product by the half sum. Lastly, Extract the square root, and you have the superficial

superficial content. So 3 multiplied by 17 makes 51; which multiplied by 33, makes 1683; that, multiplied by 53, the half sum makes 89199; the square root of which is 298, the content required.



C H A P. XIII.

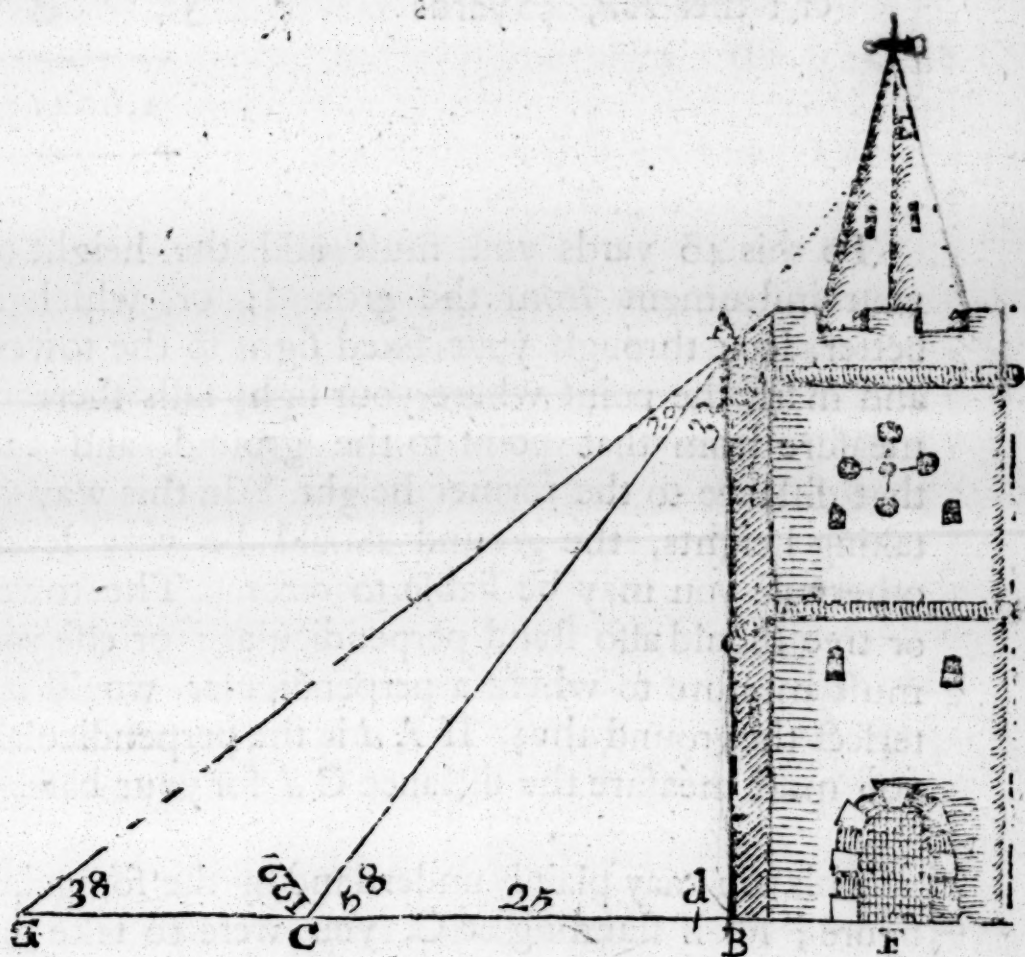
Of Heights and Distances.

To take the height of a tower, steeple, tree, or any such thing.

LET AB be a tower whose height you would know.

First, At any convenient distance, as at C, place your semicircle, or such other instrument you judge most fit for the taking an angle of altitude, as a large quadrant or the like, and there observe the angle ACB. But to be more plain, place your semicircle horizontally at C, by making a plummet-line fixed to the center fall just upon 90 deg. (in some semicircles there is a line on the back side of the brass limb, on purpose for the setting it horizontal.) Then, (first screwing the instrument fast) move the index up and down, 'till through the sights you espy the top of the tower at A, see then what degree upon the limb is cut by the index, suppose

suppose 58, so much is your angle of altitude. Measure next the distance BC d , between your instrument and the foot of the tower, which let be 25



yards; then have you all the angles known, (admitting the angle the tower makes with the ground, viz. d to be a right angle) and the base to find the perpendicular AB ; which you may do, by *Case I.* of *Trigonometry*; thus,

N 3

As

As the sine of the angle A at 32	9.724210
is to the log. of the base Cd 25	1.397940
So is the sine of the angle at C 58	9.928420
to the log. height of the tower A B, } or rather Ad , 40 yards	11.326360
	1.602150

To this 40 yards you must add the height of your instrument from the ground; or, which is better, look through your fixed sight to the tower, and mark the point where your sight falls thereon, measure from that point to the ground, and add that distance to the former height. In this way of taking heights, the ground should be very level, otherwise you may be liable to error. The tower or tree should also stand perpendicular: or else you must measure to where a perpendicular would intersect the ground thus, If Ad is the perpendicular, you must measure the distance Cd for your base.

This you may plainly understand by the foregoing figure; for if standing at C, you were to take the height of the tower and steeple to E, the angle ECB would be the same as the angle at ACB ; and consequently, if you measure only CB , or Cd , you will make the height FE the same as dA ; which by the figure is manifestly wrong: therefore to take the height FE , you must measure from C to F.

To take the height of a tower, &c. when you cannot come near the foot thereof.

In the foregoing figure, let AB represent the tower; and CB a moat, or some other hindrance, that you cannot come nigher than C to take the height. Therefore at C place your instrument, and take (as before) the angle ACB 58 deg. Then go backward any convenient distance, as to G ; there also take the angle AGB 38 deg. This done subtract 58 from 180 , so have you 122 deg. the angle ACG . Then 122 and 38 being taken from 180 , remain 20 for the angle GAC . The distance GC measured, is 26 . Now by *Trigonometry* say,

As the sine of the angle A 20	9,534052
is to the log. of the distance GC 26	1,414973
So is the sine of the angle G 38	9,789342
	11,204315
to the log. of the line AC 47	1,670263

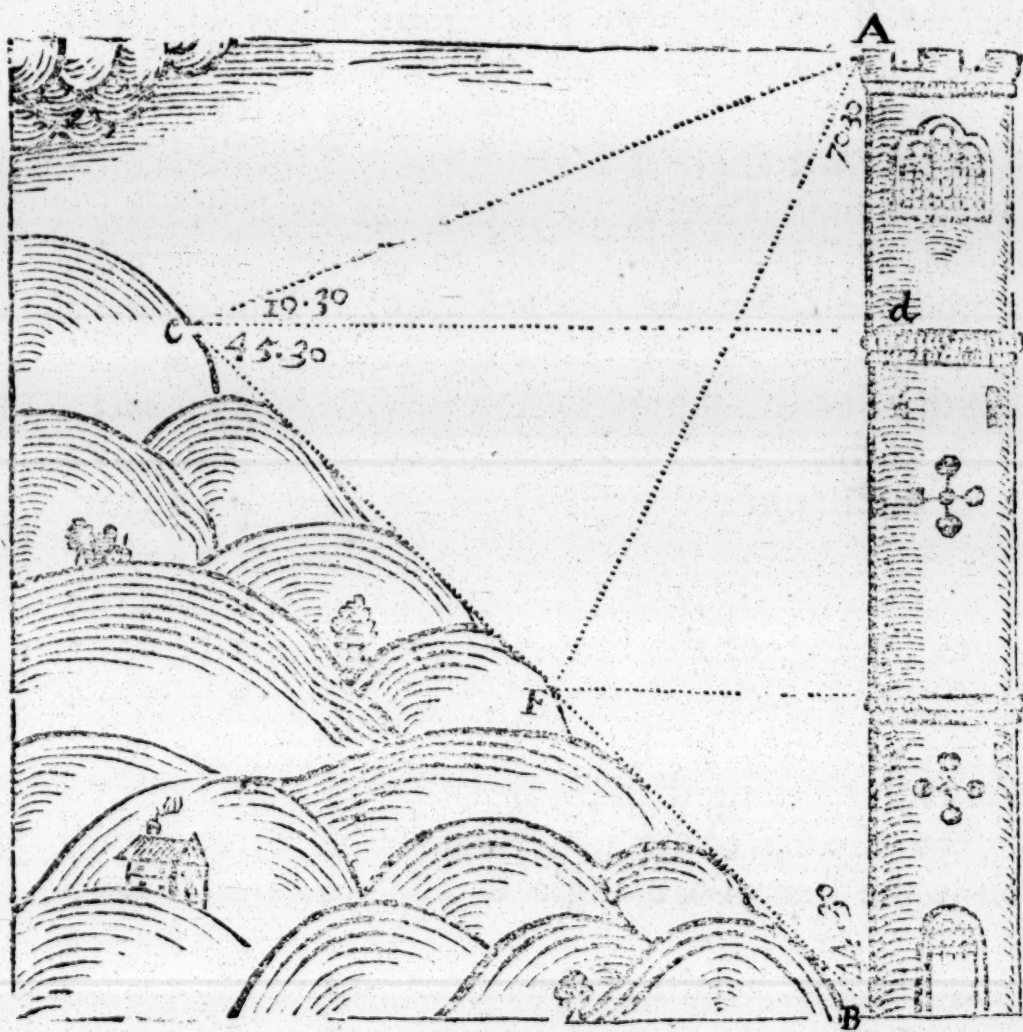
Again,

As radius the right angle B	10,000000
is to the log. of the line AC 47	1,4672098
So is the sine of the angle C 58	9,928420
to the log. height of the tower 40 } yards	11,600518

In this example, the ground is understood to be level. However, if it be not so, I will shew you,

How to take the height of a tower, &c. when the ground either riseth or falleth.

A B is the tower, C B the hill whereon you are stationed to take the height of the tower ; plant



your semicircle in any place of the hill, as at C ; then turn it down, and make it stand horizontal, as before directed, the diameter then pointing to *d* of the

Heights and Distances.

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the tower, turn the moveable index to A, and take the angle ACd ; which let be 19 degrees, 30 minutes. Take also the angle dCB , which is 45 degrees, 30 minutes; measure also the distance CB 56 yards; take 19 degrees, 30 minutes, out of 90 degrees, 0 minutes, there remains 70 degrees, 30 minutes, for the angle at A; then say,

As fine $70^{\circ} 30'$	9,974346
is to the distance CB 56 yards, log.	1,748188
So is the sum of the angles at C $19^{\circ} 30'$,	} 9,957275
and $45^{\circ} 30'$, viz. $65^{\circ} 0'$ fine	

11,705464

to the height of the tower 54 yards, log. 1,731118

To take this at two stations, without approaching the foot of the tower, you must proceed as before directed; for if you take the angles at C, and then measure to F, and there in like manner as before, take your angles again, thereby you may find all the angles, and the line AF; then say,

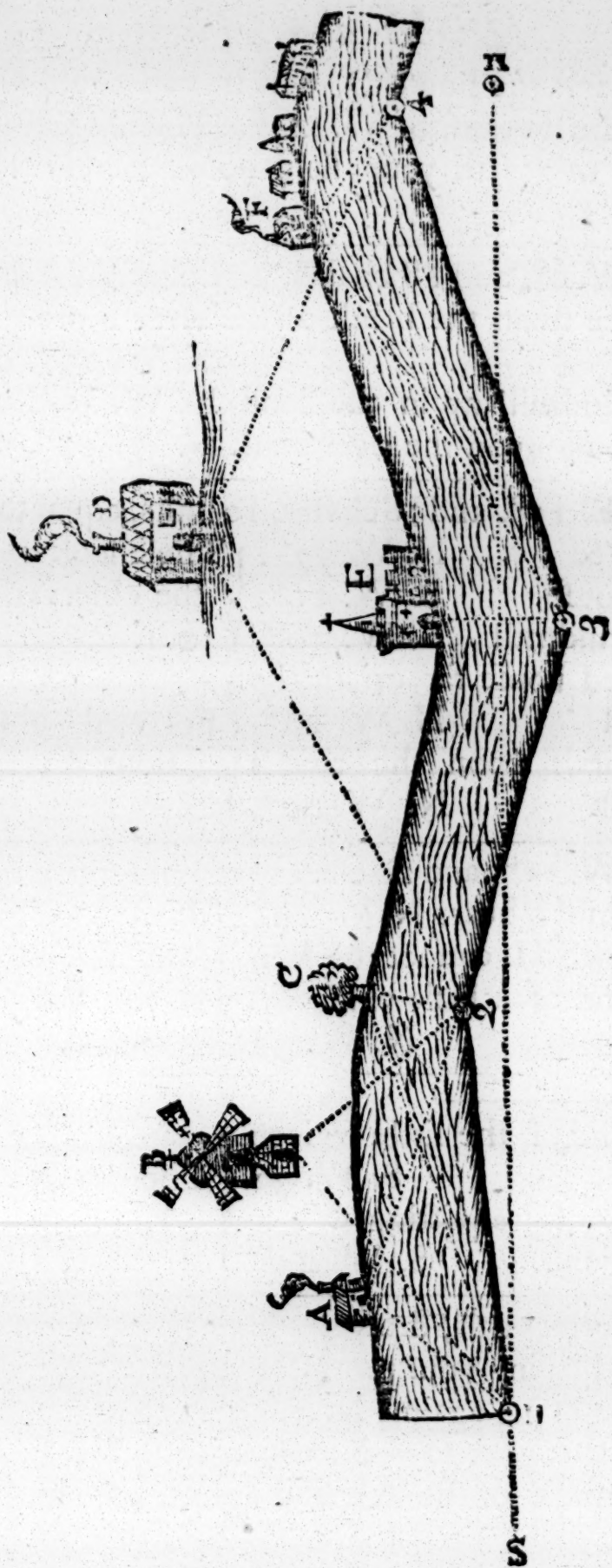
As the sine of the angle ABF
 is to the logarithm of the line FA,
 So is the sine of the angle AFB
 to the log of the height of the tower AB.

Of Distance.

Having before shewed how to take the proper distances in surveying a field at two stations, yet as it naturally occurs in this place I will give you one example thereof: suppose the following figure to be

part of a river, and you being measuring along one side of it, all desirous to know the breadth of it, as also to make a true plot thereof, by putting down what remarkable things are seen on the other side.

Beginning at $\odot$ 1, the first station, cause one of your assistants to go to the next bend of the river, as $\odot$ 2, and there set up a mark, then observe what angle from the meridian $\odot$ 1, $\odot$ 2 makes, which let be N. 6 deg. W.: also seeing several marks on the other side of the river, take their bearings, as the house A, which stands upon the bank, the breadth of the river bears N. W. 52 deg. the wind-mill B up in the land bears N. W. 40 deg. the tree C by the water-side bears N. W. 17 deg. All this note down in your field-book, and measure the distance $\odot$ 1, $\odot$ 2, 18 chains, 20 links. After this, coming to $\odot$ 2, see how the next bend of the river bears from you, *viz.* $\odot$ 3, which is N E 15 deg. see also how the house A there bears from you *viz.* S. W. 20 deg. the wind-mill S. W. 50 deg. the tree N. W. 77. Also as you are going forward, if you see any thing more at this second station, taking the bearing thereof, as a noted house D up in the land bears N. W. 28°. and a church E close by the river's brink N. W. 4°. Measure the distance 2, 3, and placing your instrument at 3, the church bears from you N. W. 88 deg. the house up in the land D you cannot see for the church, therefore let it alone for the next station. But here you may see forward a little village F, the first house whereof bears from you N. W. 32 deg. Measure the distance 3, 4, and planting your instrument in 4, the first house of the village F bears from you S. W. 30 deg. and the
house



32 deg. and the house D, which you could not see at the third station, S. W. 24° . Having put down all these things in your field-book, it will appear thus :

○ 1 N. W. 6^o. and 18 chains, 20 links, equal to ○ 2.

Observation. { A tree upon the brink of the river bears N. W. 17°. 00'.
 { A windmill up in the land N. W. 40°. 00'.
 { A house upon the river bank N. W. 52°. 00'.

○ 2 N.E. 15° . and 18 chains, 10 links, equal to ○ 3.

{	The tree	N. W. 77°.	} These look back to the observation of ☉ I.
	The house	S. W. 20°.	
	The windmill	S. W. 50°.	

{ A noted house far up in the
 land N. W. 28°. } Forward observa-
 { A church upon the river's } tions.
 bank N. W. 40°. }

⊙ 3 N.W. 15°. and 20 chains, 50 links, equal to ⊙ 4.

{ The church bears N. W. 88° . } These look back to
 { the noted H. cannot be seen. } the obs. of $\odot$ 2.
 { The end of a little village. } A forward obser-
 { N. W. 32 . } vation.

○⁴
 { The end of the little village.
 S. W. 32. } These respect ○ 3
 { The house respecting ○ 2 in
 the land. S. W. 24°. } and ○ 2.

To protract this, draw the line N. S. for a meridian, and laying your protractor upon it, the center thereof to $\odot 1$; against N. W. 6° . make a mark for the line that goes to $\odot 2$: also against N. W. 17° . make a mark for the tree, and against 40° . and 52° ,
for

for the windmill and house. Then from $\odot 1$ through these marks, draw the lines $\odot A$, $\odot B$, $\odot C$, $\odot 2$.

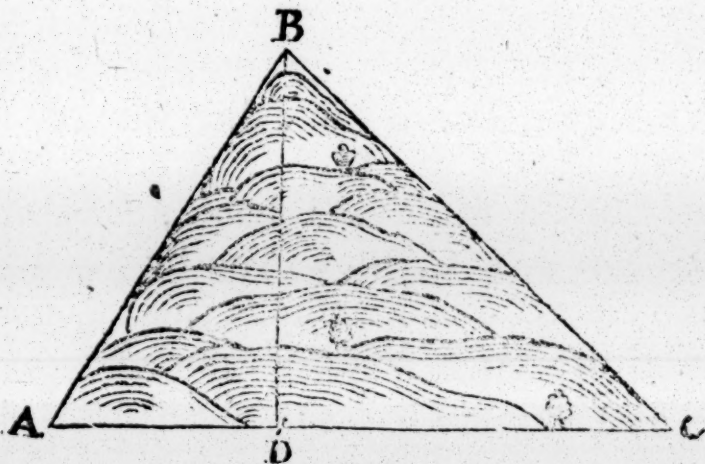
Secondly, Take from your scale 18 ch. 20 lin. and set it off upon the line $\odot 2$, which will reach from $\odot$ to 2. There lay again the center of your protractor, the diameter thereof parallel to the line N. S.; and make marks as you see in the field-book, against N. E. 15° . N. W. 77° . S. W. 20° . S. W. 50° . N. W. 28° . N. W. 4° . and through these marks draw lines. The first line directs to your third station, the second line N. W. 70° . directs you to the tree C upon the river's bank; for that line cutting the line $\odot 1 C$, shews you by the intersection where the tree stood, and also the breadth of the river. Also the line S. W. 20° . cuts the line from the first station N. W. 52° . in the place where the house A stands upon the bank of the river. If therefore you draw a line from A to C, it will represent the farther bank of the river. And so you may proceed on plotting, according to the notes in your field-book; and you will not only have a true plot of the river, but also know how far the windmill B, and the house D, &c. stand from the water-side.

How to take the horizontal line of a hill.

When you measure a hill, you must measure the superficies thereof, and accordingly cast up the contents. But when you plot it down, because you cannot make a convex superficies upon the paper, you must only plot the horizontal or base thereof; which you must shadow over with the resemblance of a hill, that other surveyors, when examining your

your work, may not say you were mistaken. This horizontal or base line, you may find after the same manner as you have been taught in taking heights.

For suppose A B C A a hill, whose base you would know. Place your semicircle at A, and cause a mark to be set up at B, as high above the top of



the hill, as the instrument stands from the ground at A; and with your instrument horizontal, take the angle B A C 58 deg. Measure the distance A B 16 chains, 80 links; then say,

As radius	10,000000
is to the line A B 16 ch. 80 lin.	3,225309
So is the fine complement of A 58°	9,724210
	—————

to A D (made by the perpendicular B D) 8 ch. 90 lin.

12,949519
—————

But if you have occasion to measure the whole hill, place again your instrument at B, and take the angle C B D, which suppose 46 deg. Measure also the distance B C 21 chains; then say,

As

Heights and Distances.

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As Radius	10,000000
is to the line B C 21 ch. (log.)	1,322219
So is the sine of the angle C B D 46	9,856934
to the remaining part of the base D C	
15 ch. 11 L.	11,179153

Which added to 8.90 makes 24 chains, 1 link, for the whole base A C; which is to be plotted, instead of A B or B C; although they were used in finding the content of the land.

I mentioned this way, for your better understanding how to take the base of part of a hill; for it often happens your survey ends upon the side of a hill. But if you find you are to take in the whole hill, you may facilitate the work by the former way. Thus: take, as before, the angle at A 58 deg. Measure also A B. Then at B take the whole angle A B C 78 deg. Subtract the sum of these angles from 180 deg. remains 44 for the angle at C; then say,

As the sine of the angle C
is to the log. of the side A B,
So is the sine of the angle A B C
to the log. of the base A C.

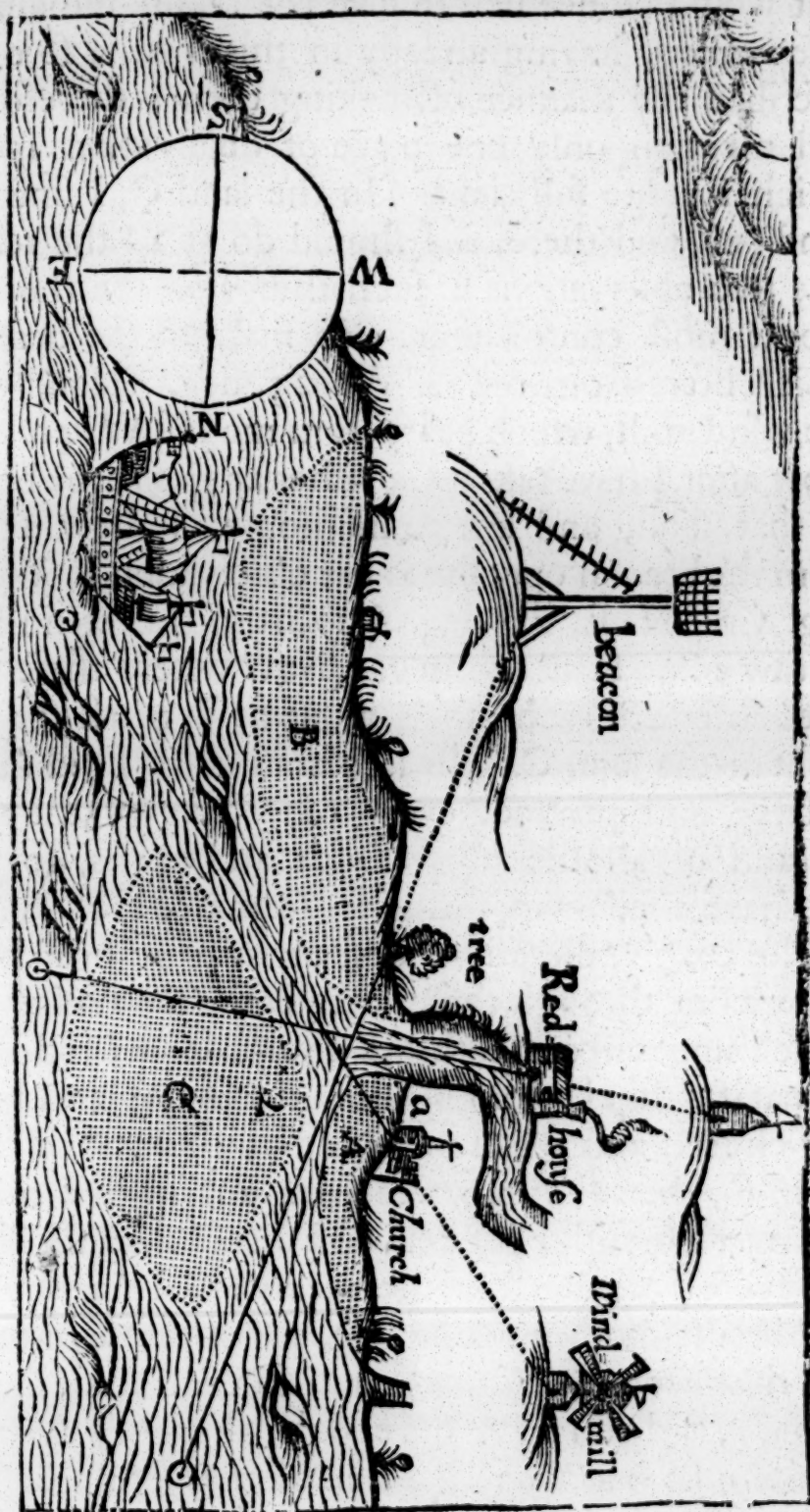
To take the shoals of a river's mouth, and plot the same.

Measure first the sea-coast on both sides of the river's mouth, as far as you think you shall have occasion to make use thereof; and make a fair draught thereof, putting down every remarkable thing in it's true situation, as trees, houses, towns, wind-mills, &c. Then going out in a boat to such
sands

sands or rocks as make the entrance difficult, at every considerable bend of the sands, take with a sea-compass the bearing thereof to two known marks upon the shore; and having thus surveyed round all the sands and rocks, you may easily, upon the plot before taken, draw lines which shall intersect each other at every considerable point of the sands, whereby you may truly point out the sands, and give directions either for laying buoys, or making marks upon the shore for the direction of shipping.

E X A M P L E.

Suppose the following figure represent a part of some sea-coast. First, I make a fair draught of it, with the mouth of the river as far up as there is occasion, putting down every thing remarkable as you see in the figure, except the rocks and sand, which I shall now shew you how to take. Go in a boat down the river, till you find the beginning of the first sand *A* as at *a*, and there take a sight to the red house, which bears S. W. 86 deg. also to the tree, which lies S. E. 6 deg. To plot which, draw lines in opposite directions to your observations; as from the red-house draw a line N. E. 86. and from the tree a line N. W. 6 deg. those lines will intersect each other in the point *a*, which shews the beginning of the sand *A*. Row along this sand, sounding as you go, 'till you find it bends considerably, and there take again two observations, and protract them as before. The like do at the bending of every sand, 'till either you come
round



round the sand or come to the place where it joins
with the shore.

O

It

It would be needless to give you all the remaining observations, having already in this treatise so often described the manner of making them; therefore I will mention only one place of observation more, which I judge sufficient. In the sand C, I find the bend (2), and there, as I should do at all the rest, I take two observations to such things on the shore as appear most conspicuous, *viz.* first, to the beacon, which bears from me S. W. 25. deg. secondly to the wind-mill, which bears from me N. W. 40. deg. Now after I have taken the other angles at the bends of that sand, and am come home, I draw a line from the beacon opposite to my observation S. W. 25 deg. *viz.* N. E. 25 deg. Also from the wind-mill I draw a line S. E. 40 deg. Now where these two lines intersect each other, as at 2, I mark for one point of the sand C. In like manner as I did this, I observe and protract every other line of the sand C, and of all the other sands and rocks, so will you have a fair map, fitting for seamen's use.

Now to give directions for seamen's coming in here, draw a line through the middle of the south channel; which line will cut both the church and wind-mill; so that if a ship be coming from the southward, bring the church and wind-mill both into one, and keep them so, then she may safely run in, 'till she brings the river's mouth fair open, and then sail up the river. Likewise if coming from the northward, bring the tree and beacon both into one line, and keep them so 'till the river's mouth is fair open. But lest they should mistake, and run upon the ends of the sands A or B, it would be necessary that a mark was set up behind the red house, in a strait line with the middle of the river, as .

Then

Then a ship coming from the southward, or northward, must keep her former marks both in one, 'till she bring the red-house and  both in one line; and keeping them so, she may run boldly up the river, 'till all danger is past. I have put down this wind-mill and beacon, not as if such good marks would always happen; but to shew you how to place marks, or lay buoys if it be required.

You must, after having taken all the sands, also take the sounding quite cross the channels, all up and down, and put them down accordingly; the best time of which, is at low-water in spring-tides.

To know whether water may be made to run from a spring head to any appointed place.

For this work, the diameter of the semicircle is a little too short; however, an indifferent shift may be made therewith; but it is better to get a water-level, such as you may buy at the instrument-makers; with which being provided, as also with two assistants, and each of them with a staff divided into feet, inches, and parts of an inch, go to the spring-head; and causing your first assistant to stand there with his staff perpendicular, make the other go in a right line towards the place designed for bringing the water any convenient distance, as 100, 150, or 200 yards, and there let him stand, and hold his staff perpendicular also. Then set your instrument nigh the mid-way between 'em, making it stand level or horizontal; and look through the sights thereof to your first assistant's staff, he moving a piece of white paper up and down the staff, according to the signs you make to him, 'till through the sights you see just the edge of the paper. Then by a sign give him

to understand that you have done with him; and let him write it down how many feet, inches, and parts the paper rested upon. Also going to the other end of your level, do the same by the second assistant, and let him write down also what number of feet, &c. the paper was from the ground. This done, let your first assistant come to the second assistant's place, and there let him again stand with his staff; and let the second assistant go forward 100, or 200 yards as before; and placing yourself and instrument in the midst between them, take your observations altogether as before, and let them be put down as before. And so must you do till you come to the place to which the water is to be conveyed. Then examine the notes of both your assistants, and if the notes of the second assistant exceed those of the first, you may be sure the place is lower than the spring-head, and that therefore water may be conveyed thence. But if the first's notes exceed the second's you may conclude it impossible without being raised by some engine for that purpose.

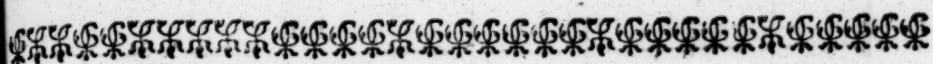
The first Assistant's Note.

Stat.	Feet.	Inch.	Parts.
⊙ 1	4	3	5
⊙ 2	12	4	2
⊙ 3	3	5	1
	20	0	8

The second Assistant's Note.

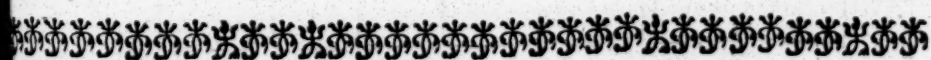
Stat.	Feet.	Inch.	Parts.
⊙ 1	14	5	1
⊙ 2	4	6	3
⊙ 3	9	2	4
	28	1	8

Here the second assistant's note exceeds the first, 8 feet, 1 inch; which is enough to bring the water with a strong current, and to make it also rise up 6 or 7 feet in the house, if occasion be; for such as have written of this matter, allow but 4 inches and $\frac{1}{2}$ fall in a mile to make the water run.



A
T A B L E
O F T H E

Northings or Southings, Eastings or Westings,
of every Degree from the Meridian, ac-
cording to the Number of Chains run
upon any DEGREE.



Easting or Westing.

4 Deg.			5 Deg.			6 Deg.		
Distance.	N	S EW	Distance.	N	S EW	Distance.	N	S EW
1	1.0	.1	1	1.0	.1	1	1.0	.1
2	2.0	.1	2	2.0	.2	2	2.0	.2
3	3.0	.2	3	3.0	.3	3	3.0	.3
4	4.0	.3	4	4.0	.3	4	4.0	.4
5	5.0	.3	5	5.0	.4	5	5.0	.5
6	6.0	.4	6	6.0	.5	6	6.0	.6
7	7.0	.5	7	7.0	.6	7	7.0	.7
8	8.0	.6	8	8.0	.7	8	8.0	.8
9	9.0	.6	9	9.0	.8	9	8.0	.9
10	10.0	.7	10	10.0	.9	10	9.9	1.0
20	20.0	1.4	20	20.0	1.7	20	19.9	2.1
30	29.9	2.1	30	29.9	2.6	30	29.8	3.1
40	39.9	2.8	40	39.8	3.5	40	39.8	4.2
50	49.9	3.5	50	49.8	4.4	50	49.7	5.2
60	59.9	4.2	60	59.8	5.2	60	59.7	6.3
70	69.8	4.9	70	69.7	6.1	70	69.6	7.3
80	79.8	5.6	80	79.7	7.0	80	79.6	8.3
90	89.8	6.3	90	89.7	7.9	90	89.5	9.4
100	99.8	7.0	100	99.6	8.7	100	99.5	10.4
Dist.	EW	N S	Dist.	EW	N S	Dist.	EW	N S
	86 Deg.			85 Deg.			84 Deg.	

A Table of Northing or Southing,

7 Deg.			7 Deg.			9 Deg.		
Distance.	N	SEW	Distance.	N	SEW	Distance.	N	SEW
1	1.0	.1	1	1.0	.1	1	1.0	.2
2	2.0	.2	2	2.0	.3	2	2.0	.3
3	3.0	.4	3	3.0	.4	3	3.0	.5
4	4.0	.5	4	4.0	.6	4	4.0	.6
5	5.0	.6	5	5.0	.7	5	5.0	.8
6	6.0	.7	6	5.9	.8	6	5.9	.9
7	6.9	.8	7	6.9	1.0	7	6.9	1.1
8	7.9	1.0	8	7.9	1.1	8	7.9	1.3
9	8.9	1.1	9	8.9	1.3	9	8.9	1.4
10	9.9	1.2	10	9.9	1.4	10	9.9	1.6
20	19.9	2.4	20	19.8	2.8	20	19.8	3.1
30	29.8	3.7	30	29.7	4.2	30	29.6	4.7
40	39.7	4.9	40	39.6	5.6	40	39.5	6.3
50	49.6	6.1	50	49.5	7.0	50	49.4	7.8
60	59.6	7.3	60	59.4	8.3	60	59.8	9.4
70	69.5	8.5	70	69.3	9.7	70	69.1	10.9
80	79.4	9.8	80	79.2	11.1	80	79.0	12.5
90	89.3	11.0	90	89.1	12.5	90	88.9	14.1
100	99.3	12.2	100	99.0	13.9	100	98.8	15.6
Diff.	EW	N S	Diff.	EW	N S	Diff.	EW	N S
	83 Deg.			82 Deg.			81 Deg.	

Easting or Westing.

10 Deg.			11 Deg.			12 Deg.		
Distance.	N	SEW	Distance.	N	SEW	Distance.	N	SEW
1	1.0	.2	1	1.0	.2	1	1.0	.2
2	2.0	.3	2	2.0	.4	2	2.0	.4
3	3.0	.5	3	2.9	.6	3	2.9	.6
4	3.9	.7	4	3.9	.8	4	3.9	.8
5	4.9	.9	5	4.9	.9	5	4.9	1.0
6	5.9	1.0	6	5.9	1.1	6	5.9	1.2
7	6.9	1.2	7	6.9	1.3	7	6.9	1.5
8	7.9	1.4	8	7.8	1.5	8	7.8	1.7
9	8.9	1.6	9	8.8	1.7	9	8.8	1.9
10	9.9	1.7	10	9.8	1.9	10	9.8	2.1
20	19.7	3.5	20	19.6	3.8	20	19.6	4.2
30	29.6	5.2	30	29.4	5.7	30	29.3	6.2
40	39.4	6.9	40	39.3	7.6	40	39.1	8.3
50	49.2	8.7	50	49.1	9.5	50	48.9	10.4
60	59.1	10.4	60	58.9	11.4	60	58.7	12.5
70	68.9	12.1	70	68.7	13.4	70	68.5	14.6
80	78.8	13.9	80	78.5	15.3	80	78.3	16.6
90	88.6	15.6	90	88.3	17.2	90	88.0	18.7
100	98.5	17.4	100	98.1	19.1	100	97.8	20.8
Dist.	EW	N S	Dist.	EW	N S	Dist.	EW	N S
80 Deg.			79 Deg.			78 Deg.		

A Table of the Northing or Southing,

13 Deg.			14 Deg.			15 Deg.		
Distance.	N	SEW	Distance.	N	SEW	Distance.	N	SEW
	---	---		---	---		---	---
1	1.0	.2	1	1.0	.2	1	1.0	.3
2	2.0	.4	2	1.9	.5	2	1.9	.5
3	2.9	.7	3	2.9	.7	3	2.9	.8
4	3.9	.9	4	3.9	1.0	4	3.9	1.0
5	4.9	1.1	5	4.8	1.2	5	4.8	1.3
6	5.9	1.3	6	5.8	1.4	6	5.8	1.6
7	6.8	1.6	7	6.8	1.7	7	6.8	1.8
8	7.8	1.8	8	7.8	1.9	8	7.7	2.1
9	8.8	2.0	9	8.7	2.2	9	8.7	2.3
10	9.8	2.2	10	9.7	2.4	10	9.7	2.6
20	19.5	4.5	20	19.4	4.8	20	19.3	5.2
30	29.2	6.7	30	29.1	7.3	30	29.0	7.8
40	39.0	9.0	40	38.8	9.7	40	38.6	10.3
50	48.7	11.2	50	48.5	12.1	50	48.3	12.9
60	58.5	13.5	60	58.2	14.5	60	58.0	15.5
70	68.2	15.7	70	67.9	16.9	70	67.6	18.1
80	78.0	18.0	80	77.6	19.4	80	77.3	20.7
90	87.7	20.2	90	87.3	21.8	90	86.9	23.3
100	97.4	22.5	100	97.0	24.2	100	96.6	25.9
Dift.	EW	N S	Dift.	EW	N S	Dift.	EW	N S
	---	---		---	---		---	---
77 Deg.			76 Deg.			75 Deg.		

Easting or Westing.

16 Deg.			17 Deg.			18 Deg.		
Distance.	N	S E W	Distance.	N	S E W	Distance.	N	S E W
1	1.0	.3	1	1.0	.3	1	1.0	.3
2	1.9	.6	2	1.9	.6	2	1.9	.6
3	2.9	.8	3	2.9	.9	3	2.8	.9
4	3.8	1.1	4	3.8	1.2	4	3.8	1.2
5	4.8	1.4	5	4.8	1.5	5	4.7	1.5
6	5.8	1.7	6	5.7	1.7	6	5.7	1.8
7	6.7	1.9	7	6.7	2.0	7	6.6	2.2
8	7.7	2.2	8	7.6	2.3	8	7.6	2.5
9	8.6	2.5	9	8.6	2.6	9	8.5	2.8
10	9.6	2.8	10	9.6	2.9	10	9.5	3.1
20	19.2	5.5	20	19.1	5.8	20	19.0	6.2
30	28.8	8.3	30	28.7	8.8	30	28.5	9.3
40	38.4	11.0	40	38.3	11.7	40	38.0	12.4
50	48.1	13.8	50	47.8	14.6	50	47.6	15.4
60	57.7	16.5	60	57.4	17.5	60	57.1	18.5
70	67.3	19.3	70	66.9	20.5	70	66.6	21.6
80	76.9	22.0	80	76.5	23.4	80	76.1	24.7
90	86.5	24.8	90	86.1	26.3	90	85.6	27.8
100	96.1	27.6	100	95.6	29.2	100	95.1	30.9
Diff.	EW	N S	Diff.	EW	N S	Diff.	EW	N S
74 Deg.			73 Deg.			72 Deg.		

Easting or Westing.

22 Deg.			23 Deg.			24 Deg.		
Distance.	N	S E W	Distance.	N	S E W	Distance.	N	S E W
1	.9	.4	1	.9	.4	1	.9	.4
2	1.9	.7	2	1.8	.8	2	1.8	.8
3	2.8	1.1	3	2.8	1.2	3	2.7	1.2
4	3.7	1.5	4	3.7	1.6	4	3.6	1.6
5	4.6	1.9	5	4.6	1.9	5	4.6	2.0
6	5.6	2.2	6	5.5	2.3	6	5.5	2.4
7	6.5	2.6	7	6.4	2.7	7	6.4	2.8
8	7.4	3.0	8	7.4	3.1	8	7.3	3.2
9	8.3	3.4	9	8.3	3.5	9	8.2	3.7
10	9.3	3.7	10	9.2	3.9	10	9.1	4.1
20	18.5	7.5	20	18.4	7.8	20	18.3	8.1
30	27.8	11.2	30	27.6	11.7	30	27.4	12.2
40	37.1	15.0	40	36.8	15.6	40	36.5	16.3
50	46.4	18.7	50	46.0	19.5	50	45.7	20.3
60	55.6	22.5	60	55.2	23.4	60	54.8	24.4
70	64.9	26.2	70	64.4	27.3	70	63.9	28.5
80	74.2	30.0	80	73.6	31.2	80	73.1	32.5
90	83.4	33.7	90	82.8	35.2	90	82.2	36.6
100	92.7	37.5	100	92.0	39.1	100	91.3	40.7
Dift.	EW	N S	Dift.	EW	N S	Dift.	EW	N S
68 Deg.			67 Deg.			66 Deg.		

A Table of Northing or Southing,

25 Deg.			26 Deg.			27 Deg.		
Distance.	N	S E W	Distance.	N	S E W	Distance.	N	S E W
	---	---		---	---		---	---
1	.9	.4	1	.9	.4	1	.9	.5
2	1.8	.8	2	1.8	.9	2	1.8	.9
3	2.7	1.3	3	2.7	1.3	3	2.7	1.4
4	3.6	1.7	4	3.6	1.8	4	3.6	1.8
5	4.5	2.1	5	4.5	2.2	5	4.5	2.3
6	5.4	2.5	6	5.4	2.6	6	5.3	2.7
7	6.3	3.0	7	6.3	3.1	7	6.2	3.2
8	7.2	3.4	8	7.2	3.5	8	7.1	3.6
9	8.1	3.8	9	8.1	3.9	9	8.0	4.1
10	9.1	4.2	10	9.0	4.4	10	8.9	4.5
20	18.1	8.4	20	18.0	8.8	20	17.8	9.1
30	27.2	12.7	30	27.0	13.1	30	26.7	13.6
40	36.2	16.9	40	36.0	17.5	40	35.6	18.2
50	45.3	21.1	50	44.9	21.9	50	44.5	22.7
60	54.4	25.4	60	53.9	26.3	60	53.5	27.2
70	63.4	29.6	70	62.9	30.7	70	62.4	31.8
80	72.5	33.8	80	71.9	35.1	80	71.3	36.3
90	81.6	38.0	90	80.9	39.4	90	80.2	40.9
100	90.6	42.3	100	89.9	43.8	100	89.1	45.4
Dift.	EW	N S	Dift.	EW	N S	Dift.	EW	N S
	---	---		---	---		---	---
65 Deg.			64 Deg.			63 Deg.		

Easting or Westing.

28 Deg.			29 Deg.			30 Deg.		
Distance.	N	SEW	Distance.	N	SEW	Distance.	N	SEW
1	.9	.5	1	.9	.5	1	.9	.5
2	1.8	.9	2	1.7	1.0	2	1.7	1.0
3	2.6	1.4	3	2.6	1.4	3	2.6	1.5
4	3.5	1.9	4	3.5	1.9	4	3.5	2.0
5	4.4	2.3	5	4.4	2.4	5	4.3	2.5
6	5.3	2.8	6	5.2	2.9	6	5.2	3.0
7	6.2	3.3	7	6.1	3.4	7	6.1	3.5
8	7.1	3.7	8	7.0	3.9	8	6.9	4.0
9	7.9	4.2	9	7.9	4.3	9	7.8	4.5
10	8.8	4.7	10	8.7	4.8	10	8.7	5.0
20	17.7	9.4	20	17.5	9.7	20	17.3	10.0
30	26.5	14.1	30	26.2	14.5	30	26.0	15.0
40	35.3	18.8	40	35.0	19.4	40	34.6	20.0
50	44.1	23.5	50	43.7	24.2	50	43.3	25.0
60	53.0	28.2	60	52.5	29.1	60	52.0	30.0
70	61.8	32.9	70	61.2	33.9	70	60.6	35.0
80	70.6	37.6	80	70.0	38.8	80	69.3	40.0
90	79.5	42.2	90	79.7	43.6	90	77.9	45.0
100	88.3	46.9	100	87.5	48.5	100	86.6	50.0
Dift.	EW	N S	Dift.	EW	N S	Dift.	EW	N S
62 Deg			61 Deg.			60 Deg.		

A Table of Northing or Southing,

31 Deg.			32 Deg.			33 Deg.		
Distance.	N	S E W	Distance.	N	S E W	Distance.	N	S E W
	---	---		---	---		---	---
1	.9	.5	1	.8	.5	1	.8	.5
2	1.7	1.0	2	1.7	1.1	2	1.7	1.1
3	2.6	1.5	3	2.5	1.6	3	2.5	1.6
4	3.4	2.1	4	3.4	2.1	4	3.4	2.2
5	4.3	2.6	5	4.2	2.6	5	4.2	2.7
6	5.1	3.1	6	5.1	3.2	6	5.0	3.3
7	6.0	3.6	7	5.9	3.7	7	5.9	3.8
8	6.9	4.1	8	6.8	4.2	8	6.7	4.4
9	7.7	4.6	9	7.6	4.8	9	7.6	4.9
10	8.6	5.1	10	8.5	5.3	10	8.4	5.4
20	17.1	10.3	20	17.0	10.6	20	16.8	10.9
30	25.7	15.4	30	25.4	15.9	30	25.2	16.3
40	34.3	20.6	40	33.9	21.2	40	33.5	21.8
50	32.9	25.7	50	42.4	26.5	50	41.9	27.2
60	51.4	30.9	60	50.9	31.8	60	50.3	32.7
70	60.0	36.0	70	59.4	37.1	70	58.7	38.1
80	68.6	41.2	80	67.8	42.4	80	67.1	43.6
90	77.1	46.3	90	76.3	47.7	90	75.5	49.0
100	85.7	51.5	100	84.8	53.0	100	83.9	54.5
Diff.	E W	N S	Diff.	E W	N S	Diff.	E W	N S
	---	---		---	---		---	---
59 Deg.			58 Deg.			57 Deg.		

Easting or Westing.

34 Deg.			35 Deg.			36 Deg.		
Distance.	N	SEW	Distance.	N	SEW	Distance.	N	SEW
1	.8	.6	1	.8	.6	1	.8	.6
2	1.7	1.1	2	1.7	1.1	2	1.6	1.2
3	2.5	1.7	3	2.5	1.7	3	2.4	1.8
4	3.3	2.2	4	3.3	2.3	4	3.2	2.3
5	4.1	2.8	5	4.1	2.9	5	4.0	2.9
6	5.0	3.4	6	4.9	3.4	6	4.8	3.5
7	5.8	3.9	7	5.7	4.0	7	5.6	4.1
8	6.6	4.5	8	6.6	4.6	8	6.4	4.7
9	7.5	5.0	9	7.4	5.2	9	7.2	5.3
10	8.3	5.6	10	8.2	5.7	10	8.1	5.9
20	16.6	11.2	20	16.4	11.5	20	16.2	11.8
30	24.9	16.8	30	24.6	17.2	30	24.3	17.6
40	33.2	22.4	40	32.8	22.9	40	32.4	23.5
50	41.4	28.0	50	41.0	28.7	50	40.4	29.4
60	49.7	33.5	60	49.1	34.4	60	48.5	35.3
70	58.0	39.1	70	57.3	40.2	70	56.6	41.1
80	66.3	44.7	80	65.5	45.9	80	64.7	47.0
90	74.6	50.3	90	73.7	51.6	90	72.8	52.9
100	82.9	55.9	100	81.9	57.4	100	80.9	58.8
Dist.	EW	N S	Dist.	EW	N S	Dist.	EW	N S
56 Deg.			55 Deg.			54 Deg.		

A Table of Northing or Southing,

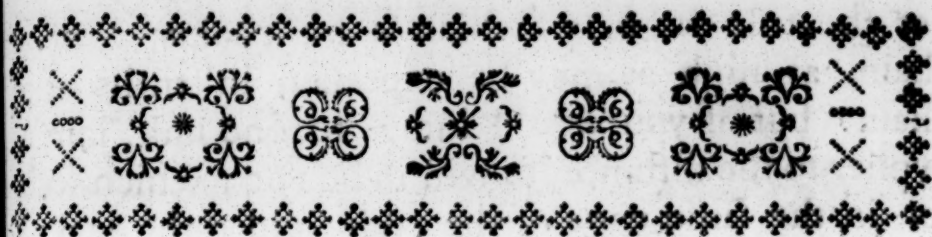
37 Deg.			38 Deg.			39 Deg.		
Distance.	N	S EW	Distance.	N	S EW	Distance.	N	S EW
1	.8	.6	1	.8	.6	1	.8	.6
2	1.6	1.2	2	1.6	1.2	2	1.6	1.3
3	2.4	1.8	3	2.4	1.8	3	2.3	1.9
4	3.2	2.4	4	3.1	2.5	4	3.1	2.5
5	4.0	3.0	5	3.9	3.1	5	3.9	3.1
6	4.8	3.6	6	4.7	3.7	6	4.7	3.8
7	5.6	4.2	7	5.5	4.3	7	5.4	4.4
8	6.4	4.8	8	6.3	4.9	8	6.2	5.0
9	7.2	5.4	9	7.1	5.5	9	7.0	5.7
10	8.0	6.0	10	7.9	6.2	10	7.8	6.3
20	16.0	12.0	20	15.8	12.3	20	15.5	12.6
30	24.0	18.0	30	23.6	18.5	30	13.3	18.9
40	31.9	24.1	40	31.5	24.6	40	21.1	25.2
50	39.9	30.1	50	39.4	30.8	50	38.8	31.5
60	47.9	36.1	60	47.3	36.9	60	46.6	37.8
70	55.9	42.1	70	55.2	43.1	70	54.4	44.0
80	63.9	48.1	80	63.0	49.3	80	62.2	50.3
90	71.9	54.2	90	70.9	55.4	90	69.9	56.6
100	79.9	60.2	100	78.8	61.6	100	77.7	62.9
Diff.	EW	NS	Diff.	EW	NS	Diff.	EW	NS
53 Deg.			52 Deg.			51 Deg.		

Easting or Westing.

40 Deg.			41 Deg.			42 Deg.		
Distance.	N	SEW	Distance.	N	SEW	Distance.	N	SEW
	---	---		---	---		---	---
1	.8	.6	1	.8	.7	1	.7	.7
2	1.5	1.3	2	1.5	1.3	2	1.5	1.3
3	2.3	1.9	3	2.3	2.0	3	2.2	2.0
4	3.1	2.6	4	3.0	2.6	4	3.0	2.7
5	3.8	3.2	5	3.8	3.3	5	3.7	3.3
6	4.6	3.8	6	4.5	3.9	6	4.4	4.0
7	5.4	4.5	7	5.3	4.6	7	5.2	5.7
8	6.1	5.1	8	6.0	5.2	8	5.9	5.3
9	6.9	5.8	9	6.8	5.9	9	6.7	6.0
10	7.7	6.4	10	7.5	6.6	10	7.4	6.7
20	15.3	12.9	20	15.1	13.1	20	14.9	13.4
30	23.0	19.3	30	22.6	19.7	30	22.3	20.1
40	30.6	25.7	40	30.2	26.2	40	29.7	26.8
50	38.3	32.1	50	37.7	32.8	50	37.2	33.5
60	46.0	38.6	60	45.3	39.4	60	44.6	40.1
70	53.6	45.0	70	52.8	45.9	70	52.0	46.8
80	61.3	51.4	80	60.4	52.5	80	59.4	53.5
90	68.9	57.9	90	67.9	59.0	90	66.9	60.2
100	76.6	64.3	100	75.5	65.6	100	74.3	66.9
Dift.	EW	N S	Dift.	EW	N S	Dift.	EW	N S
	---	---		---	---		---	---
50 Deg.			49 Deg.			48 Deg.		

A Table of Northing or Southing,

43 Deg.			44 Deg.			45 Deg.		
Diftance.	N	SEW	Diftance.	N	SEW	Diftance.	N	SEW
1	.7	.7	1	.7	.7	1	.7	.7
2	1.5	1.4	2	1.4	1.4	2	1.4	1.4
3	2.2	2.0	3	2.2	2.1	3	2.1	2.1
4	2.9	2.7	4	2.9	2.8	4	2.8	2.8
5	3.6	3.4	5	3.6	3.5	5	3.5	3.5
6	4.4	4.1	6	4.3	4.2	6	4.2	4.2
7	5.1	4.8	7	5.0	4.9	7	4.9	4.9
8	5.8	5.4	8	5.8	5.6	8	5.6	5.6
9	6.6	6.1	9	6.5	6.2	9	6.4	6.4
10	7.3	6.8	10	7.2	6.9	10	7.1	7.1
20	14.6	13.6	20	14.4	13.9	20	14.1	14.1
30	21.9	20.5	30	21.6	20.8	30	21.2	21.2
40	29.2	27.3	40	28.8	27.8	40	28.3	28.3
50	36.6	34.1	50	36.0	34.7	50	35.3	35.3
60	43.9	40.9	60	43.2	41.7	60	42.4	42.4
70	51.2	47.7	70	50.3	48.6	70	49.5	49.5
80	58.5	54.6	80	57.5	55.6	80	56.6	56.6
90	65.8	61.4	90	64.7	62.5	90	63.6	63.6
100	73.1	68.2	100	71.9	69.5	100	70.7	70.7
Dift.	EW	N S	Dift.	EW	N S	Dift.	EW	N S
47 Deg.			46 Deg.			45 Deg.		



The U S E of the foregoing
T A B L E.

I HAVE already sufficiently, in the sixth chapter of this book, explained the use of this table; however because it is made somewhat different from such of this kind as have been made by others, I will briefly, by an example or two, explain it. Admit in surveying a wood, or the like, you run a line N. E. 40 degrees, 10 chains: or which is the same thing, a line 10 chains in length, that makes an angle with the meridian of 40 degrees to the eastward; and you would put down in your Field-Book the northing and easting of this line, under their proper titles N. and E. according to Mr. Norwood's way of surveying, taught in the sixth chapter of this book.

First, at the head of the table find 40 degrees, then in the column of distances seek for 10 chains, which being had, you will find to stand right against it, under the title N. 7. 7. for the northing, which

is 7 chains, $\frac{7}{10}$ of a chain: and for the easting, under the title E. 6. 4. which is six chains, $\frac{4}{10}$ of a chain, as nigh as may be expressed in tnths of a chain: but if you would know to one link, join a cypher to the distance, so will 10 be 100; which seek for in the same page of the table, and right against it you will find under title N. 76.6, or 7 chains, 66 links for your northing; and under title E, 64.3, or 6 chains, 43 links for your easting: which found, put down in your Field Book accordingly; and having done so by all your lines, if you find the northing and southing the same, also the easting and westing, you may be sure you have wrought true, otherwise not.

If the distance consists of odd chains and links, as most commonly happens, then take them severally out of the table, and by adding all together you will have your desire. As for example:

Suppose my distance run upon any line be N. W. 35 degrees, 15 chains, 20 links: N.

	Ch.	Ch.	Lin.
First in the table I find the northing			
of 10 chains to be - - - - }	10	8	19
	5	4	10
	20	L. 0	$16\frac{4}{10}$
		12	$45\frac{4}{10}$

Which added together, makes 12 chains, 45 links $\frac{4}{10}$ for the northing of that distance run. In like manner

manner under 35 degrees and title W. I find the westing of the same line, as here:

Ch.	Ch.	Lin.
10	5	74
5	2	87
20	Lin. 0	11 $\frac{5}{10}$
	8	72 $\frac{5}{10}$

By which I conclude the northing of that line to be 12 chains, 45 links $\frac{4}{10}$, and the westing 8 chains, 72 links $\frac{5}{10}$: which thus you may prove by the logarithms.

As radius	-	-	-	-	10,000000
is to the distance 15.20	-	-	-	-	3,181844
So is the sine of the course 35 degrees					9,758591

To the westing 8 chains, 72 links	2,940345

And, as radius	-	-	-	10,000000
to the distance 15 chains, 20 links				3,181844
So co-sine of the course 55	-	-	-	9,913364

to the northing 12 chains, 45 links	3,095208

Note, If your course had been S. E. it would have been the same thing as N. W. for you see in the tables N. and S. E. and W. are joined together. If

your degrees exceed 45, then seek for them at the foot of the table: and over the titles N. S. E. W. find out the northing, southing, easting, or westing.

This I apprehend to be as much as need be said concerning the preceding table: and as for finding the horizontal line of a hill, and such other things by the table, you will find sufficient directions in the chapter of trigonometry.



A T A B L E



A

T A B L E

O F

SINES and TANGENTS

To every Fifth Minute. of the

QUADRANT.



The table of Sines and Tangents.

0					
	Sine	Co-sine.	Tangent.	Co-tang.	
0	0.000000	10.000000	0.000000	Infinita	60
5	7.162696	9.999999	7.162696	12.837304	55
10	7.463726	9.999998	7.463727	12.536273	50
15	7.639816	9.999996	7.639820	12.360180	45
20	7.764754	9.999993	7.764761	12.235239	40
25	7.861662	9.999989	7.861674	12.138326	35
30	7.940842	9.999983	7.940858	12.059142	30
35	8.007787	9.999977	8.007809	11.992191	25
40	8.065776	9.999971	8.065806	11.934194	20
45	8.116926	9.999963	8.116963	11.883037	15
50	8.162681	9.999954	8.162737	11.837273	10
55	8.204070	9.999944	8.204126	11.795874	5
60	8.241855	9.999934	8.241921	11.758079	0
	Co-sine.	Sine	Co-tang.	Tangent.	M

89.

1					
	Sine	Co-sine.	Tangent.	Co-tang.	
0	8.241855	9.999934	8.241921	11.758079	60
5	8.270614	9.999922	8.276691	11.723309	55
10	8.308794	9.999910	8.308884	11.691116	50
15	8.338753	9.999897	8.338856	11.661144	45
20	8.366777	9.999882	8.366895	11.630105	40
25	8.393101	9.999867	8.393234	11.606766	35
30	8.417919	9.999851	8.418068	11.581932	30
35	8.441394	9.999834	8.441560	11.558440	25
40	8.463665	9.999816	8.463849	11.536151	20
45	8.484848	9.999797	8.485050	11.514950	15
50	8.505045	9.999778	8.505267	11.494733	10
55	8.524343	9.999757	8.524586	11.475414	5
60	8.542810	9.999735	8.542084	11.456916	0
	Co-sine.	Sine.	Co-tang.	Tangent.	M

88

The Table of Sines and Tangents.

2.

M	Sine	Cofine.	Tangent.	Co-tang.	
0	8.542819	9.999735	8.543084	11.456916	60
5	8.560540	9.999713	8.560828	11.439172	55
10	8.577566	9.999689	8.577877	11.422123	50
15	8.593948	9.999665	8.594283	11.405717	45
20	8.609734	9.999640	8.610094	11.389906	40
25	8.624965	9.999614	8.625352	11.374648	35
30	8.639680	9.999586	8.640093	11.359907	30
35	8.653911	9.999558	8.654352	11.345648	25
40	8.667689	9.999529	8.668160	11.331840	20
45	8.681043	9.999500	8.681544	11.318456	15
50	8.693998	9.999469	8.694529	11.305471	10
55	8.706577	9.999437	8.707140	11.292860	5
60	8.718800	9.999404	8.719396	11.280604	0
	Cofine.	Sine.	Co tang.	Tangent.	M

87.

3.

M	Sine.	Co-fine.	Tangent.	Co-tang.	
0	8.718800	9.999404	8.719396	11.280604	60
5	8.730688	9.999371	8.731317	11.268683	55
10	8.742250	9.999336	8.742922	11.257078	50
15	8.753528	9.999301	8.754227	11.245773	45
20	8.764511	9.999265	8.765246	11.234754	40
25	8.775223	9.999227	8.775995	11.224005	35
30	8.785675	9.999189	8.786486	11.213514	30
35	8.795881	9.999150	8.796731	11.203269	25
40	8.805852	9.999110	8.806742	11.193258	20
45	8.815599	9.999069	8.816529	11.183471	15
50	8.825130	9.999027	8.826103	11.173897	10
55	8.834456	9.998984	8.835471	11.164529	5
60	8.843585	9.998941	8.844644	11.155356	0
	Co-fine.	Sine.	Co-tang.	Tangent.	M

86.

The Table of Sines and Tangents.

4.

M	Sine.	Co-sine.	Tangent.	Co-tang.	
0	8.843585	9.99 941	8.844644	11.155356	60
5	8.852525	9.998896	8.853628	11.146372	55
10	8.861283	9.998851	8.852433	11.137567	50
15	8.869868	9.998804	8.871064	11.128936	45
20	8.878285	9.998 57	8.879529	11.120471	40
25	8.886542	9.998708	8.887833	11.112167	35
30	8.894643	9.998659	8.895984	11.104016	30
35	8.902596	9.998609	8.903987	11.096013	25
40	8.910404	9.998558	8.911846	11.088154	20
45	8.918073	9.998506	8.919568	11.080432	15
50	8.925609	9.998453	8.927156	11.072844	10
55	8.933015	9.998399	8.934616	11.065384	5
60	8.940296	9.998344	8.941952	11.058048	0
	Co-sine.	Sine.	Co-tang.	Tangent.	M

85.

5.

M	Sine.	Co sine.	Tangent.	Co-tang.	
0	8.940296	9.998344	8.941952	11.058048	60
5	8.947456	9.998289	8.949168	11.050832	55
10	8.954499	9.998232	8.956267	11.043733	50
15	8.961429	9.998174	8.963255	11.036745	45
20	8.968249	9.998116	8.970133	11.029867	40
25	8.974962	9.998056	8.976906	11.023094	35
30	8.981573	9.997996	8.983577	11.016423	30
35	8.988083	9.997935	8.990149	11.009851	25
40	8.994497	9.997872	8.996624	11.003376	20
45	9.000816	9.997809	9.003007	10.996993	15
50	9.007044	9.997745	9.009298	10.990702	10
55	9.013182	9.997680	9.015502	10.984498	5
60	9.019235	9.997614	9.021620	10.978380	0
	Co sine.	Sine.	Co-tang.	Tangent.	M

84.

The Table of Sines and Tangents.

6.

M	Sine.	Co-sine.	Tangent.	Co-tang.	
0	9.019235	9.997614	9.021620	10.978380	60
5	9.025203	9.997547	9.027655	10.972345	55
10	9.031089	9.997480	9.033609	10.966391	50
15	9.036896	9.997411	9.039485	10.960515	45
20	9.042625	9.997341	9.045284	10.954716	40
25	9.048279	9.997271	9.051008	10.948992	35
30	9.053859	9.997199	9.056659	10.943341	30
35	9.059367	9.997127	9.062240	10.937760	25
40	9.064806	9.997053	9.067752	10.932248	20
45	9.070176	9.996979	9.073197	10.926803	15
50	9.075480	9.996904	9.078576	10.921424	10
55	9.080719	9.996828	9.083891	10.916109	5
60	9.085894	9.996751	9.089144	10.910856	0
	Co-sine.	Sine.	Co-tang.	Tangent.	

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7

M	Sine.	Co-sine.	Tangent.	Co-tang.	
0	9.085894	9.996751	9.089144	10.910850	60
5	9.091008	9.996673	9.094336	10.905664	55
10	9.096062	9.996594	9.099468	10.900532	50
15	9.101056	9.996514	9.104542	10.895458	45
20	9.105992	9.996433	9.109559	10.890441	40
25	9.110873	9.996351	9.114521	10.885479	35
30	9.115698	9.996269	9.119429	10.880571	30
35	9.120469	9.996185	9.124284	10.875716	25
40	9.125187	9.996100	9.129087	10.870913	20
45	9.129854	9.996015	9.133839	10.866161	15
50	9.134470	9.995928	9.138542	10.861458	10
55	9.139037	9.995841	9.143196	10.856804	5
60	9.143555	9.995753	9.147803	10.852197	0
	Co-sine.	Sine.	Co-tang.	Tangent.	M

82.

The Table of Sines and Tangents.

8.

M	Sine.	Co-sine.	Tangent.	Co-tang.	
0	9.143555	9.995753	9.147803	10.852197	60
5	9.148026	9.995604	9.152363	10.847637	55
10	9.152451	9.995573	9.156877	10.843123	50
15	9.156830	9.995482	9.161347	10.838653	45
20	9.161164	9.995390	9.165774	10.834226	40
25	9.165454	9.995297	9.170157	10.829843	35
30	9.169702	9.995203	9.174499	10.825501	30
35	9.173908	9.995108	9.178799	10.821201	25
40	9.178072	9.995013	9.183059	10.816941	20
45	9.182196	9.994916	9.187280	10.812720	15
50	9.186280	9.994818	9.191462	10.808538	10
55	9.190325	9.994720	9.195606	10.804394	5
60	9.194332	9.994620	9.199713	10.800287	0
	Co-sine.	Sine.	Co-tang.	Tangent.	M

81.

9.

M	Sine.	Co-sine.	Tangent.	Co-tang.	
0	9.194332	9.994620	9.199713	10.800287	60
5	9.198302	9.994159	9.203782	10.796218	55
10	9.202234	9.994418	9.207817	10.792183	50
15	9.206131	9.994316	9.211815	10.788185	45
20	9.209992	9.994212	9.215780	10.784220	40
25	9.213818	9.994108	9.219710	10.780290	35
30	9.217609	9.994003	9.223607	10.776393	30
35	9.221367	9.993897	9.227471	10.772529	25
40	9.225092	9.993789	9.231302	10.768698	20
45	9.228784	9.993681	9.235103	10.764897	15
50	9.232444	9.993572	9.238872	10.761128	10
55	9.236073	9.993462	9.242610	10.757390	5
60	9.239670	9.993351	9.246319	10.753681	0
	Co-sine.	Sine.	Co-tang.	Tangent.	M

80.

The Table of Sines and Tangents.

10.

M	Sine.	Co-sine.	Tangent.	Co ang	
0	9.239670	9.993351	9.246319	10.753081	60
5	9.243237	9.993240	9.249998	10.750002	55
10	9.246775	9.993127	9.253648	10.746352	50
15	9.250282	9.993013	9.257269	10.742731	45
20	9.253761	9.992898	9.260863	10.739137	40
25	9.257211	9.992783	9.264428	10.735572	35
30	9.260633	9.992666	9.267967	10.732033	30
35	9.264027	9.992549	9.271479	10.728521	25
40	9.267395	9.992430	9.274964	10.725036	20
45	9.270735	9.992311	9.278424	10.721576	15
50	9.274049	9.992190	9.281858	10.718142	10
55	9.277337	9.992069	9.285268	10.714732	5
60	9.280599	9.991947	9.288652	10.711348	0
	Co-sine.	Sine.	Co-tang.	Tangent.	M

79.

11.

M	Sine.	Co-sine.	Tangent.	Co-tang.	
0	9.280599	9.991974	9.288652	10.711348	60
5	9.283836	9.991823	9.292013	10.707987	55
10	9.287048	9.991699	9.295949	10.704651	50
15	9.290236	9.991574	9.298662	10.701338	45
20	9.293399	9.991448	9.301951	10.698049	40
25	9.296539	9.991321	9.305218	10.694782	35
30	9.299655	9.991193	9.308463	10.691537	30
35	9.302748	9.991064	9.311685	10.688315	25
40	9.305819	9.990934	9.314885	10.685115	20
45	9.308867	9.990803	9.318064	10.681936	15
50	9.311893	9.990671	9.321222	10.678778	10
55	9.314897	9.990538	9.324358	10.675642	5
60	9.317879	9.990404	9.327475	10.672525	0
	Co-sine.	Sine.	Co-tang.	Tangent.	M

78.

The Table of Sines and Tangents.

12.

M	Sine.	Co-sine.	Tangent.	Co-tang.	
0	9.317879	9.990404	9.327475	10.672525	60
5	9.320840	9.990270	9.330570	10.669430	55
10	9.323780	9.990134	9.333646	10.666354	50
15	9.326700	9.989997	9.336702	10.663298	45
20	9.329599	9.989860	9.339739	10.660261	40
25	9.332478	9.989721	9.342757	10.657243	35
30	9.335337	9.989582	9.345755	10.654245	30
35	9.338176	9.989441	9.348735	10.651265	25
40	9.340996	9.989300	9.351697	10.648303	20
45	9.343797	9.989157	9.354640	10.645360	15
50	9.346579	9.989014	9.357566	10.642434	10
55	9.349343	9.988869	9.360474	10.639565	5
60	9.352088	9.988724	9.363364	10.636636	0
	Co-sine.	Sine.	Co-tang.	Tangent.	M

77.

13.

M	Sine.	Co-sine.	Tangent.	Co-tang.	
0	9.352088	9.988724	9.363364	10.636636	60
5	9.354815	9.988578	9.366237	10.633763	55
10	9.357524	9.988430	9.369094	10.630906	50
15	9.360215	9.988282	9.371933	10.628674	45
20	9.362809	9.988133	9.374756	10.625244	40
25	9.365546	9.987983	9.377563	10.622437	35
30	9.368185	9.987832	9.380354	10.619646	30
35	9.370808	9.987679	9.383129	10.616871	25
40	9.373414	9.987526	9.385888	10.614112	20
45	9.376003	9.987372	9.388631	10.611369	15
50	9.378577	9.987217	9.391360	10.608401	10
55	9.381134	9.987061	9.394073	10.605927	5
60	9.383675	9.987904	9.396771	10.603229	0
	Co-sine.	Sine.	Co-tang.	Tangent.	

76.

The Table of Sines and Tangents.

14.

M	Sine.	Co-sine.	Tangent.	Co-tang.	
0	9.383675	9.986904	9.390771	10.603229	60
5	9.386201	9.986746	9.399455	10.600545	55
10	9.388711	9.986587	9.402124	10.597876	50
15	9.381206	9.986427	9.404778	10.595222	45
20	9.393685	9.986266	9.407419	10.592581	40
25	9.396750	9.986104	9.410045	10.589955	35
30	9.398600	9.985942	9.412658	10.587342	30
35	9.401035	9.985778	9.415257	10.584743	25
40	9.403455	9.985613	9.417842	10.582158	20
45	9.405862	9.985447	9.420415	10.579585	15
50	9.408254	9.985280	9.422974	10.577026	10
55	9.410632	9.985113	9.425519	10.574481	5
60	9.412996	9.984944	9.428052	10.571948	0
	Co-sine.	Sine.	Co-tang.	Tangent.	M

75.

15.

M	Sine.	Co-sine.	Tangent.	Co-tang.	
0	9.412996	9.984944	9.428052	10.571948	60
5	9.415347	9.984774	9.430573	10.569427	55
10	9.417684	9.984603	9.433080	10.566920	50
15	9.420007	9.984432	9.435576	10.564424	45
20	9.422318	9.984259	9.438059	10.561941	40
25	9.424615	9.984085	9.440529	10.559471	35
30	9.426899	9.983911	9.442988	10.557012	30
35	9.429170	9.983735	9.445435	10.554565	25
40	9.431429	9.983558	9.447870	10.552130	20
45	9.433675	9.983381	9.450294	10.549706	15
50	9.435908	9.983202	9.452706	10.547294	10
55	9.438129	9.983022	9.455107	10.544893	5
60	9.440338	9.982842	9.457496	10.542504	0
	Co-sine.	Sine.	Co-tang.	Tangent.	

74.

Q

The Table of Sines and Tangents.

16.

M	Sine.	Co-line.	Tangent.	Co-tang.	
0	9.440338	9.982842	9.457496	10.542504	60
5	9.442535	9.982660	9.459875	10.540125	55
10	9.444720	9.982477	9.462242	10.537758	50
15	9.446893	9.982294	9.464599	10.535401	45
20	9.449054	9.982169	9.466945	10.533055	40
25	9.451204	9.981924	9.469280	10.530720	35
30	9.453342	9.981737	9.471605	10.528395	30
35	9.455469	9.981549	9.473919	10.526081	25
40	9.457584	9.981361	9.476223	10.523777	20
45	9.459688	9.981171	9.478517	10.521483	15
50	9.461782	9.980981	9.480801	10.519199	10
55	9.463864	9.980789	9.483075	10.516925	5
60	9.465935	9.980596	9.485339	10.514661	0
	Co-line.	Sine.	Co-tang.	Tangent.	M

73.

17

M	Sine.	Co-line.	Tangent.	Co-tang.	
0	9.465935	9.980596	9.485339	10.514661	60
5	9.467996	9.980403	9.487593	10.512407	55
10	9.470446	9.980208	9.489838	10.510162	50
15	9.472086	9.980012	9.492073	10.507927	45
20	9.474115	9.979816	9.494299	10.505701	40
25	9.476133	9.979618	9.496515	10.503485	35
30	9.478142	9.979420	9.498722	10.501278	30
35	9.480140	9.979220	9.500920	10.499080	25
40	9.482128	9.979019	9.503109	10.496891	20
45	9.484107	9.978817	9.505289	10.494711	15
50	9.486075	9.978615	9.507460	10.492540	10
55	9.488034	9.978411	9.509622	10.490378	5
60	9.489982	9.978206	9.511776	10.488224	0
	Co-line.	Sine.	Co-tang.	Tangent.	M

72.

The Table of Sines and Tangents.

18.

M	Sine.	Co-sine.	Tangent.	Co-tang.	
0	9.489982	9.978206	9.511776	10.488222	60
5	9.491922	9.978001	9.513921	10.486076	55
10	9.493851	9.977794	9.516057	10.483943	50
15	9.495772	9.977586	9.518186	10.481814	45
20	9.497682	9.977377	9.520305	10.479695	40
25	9.499584	9.977167	9.522417	10.477583	35
30	9.501476	9.976957	9.524520	10.475480	30
35	9.503360	9.976745	9.526615	10.473385	25
40	9.505234	9.976532	9.528702	10.471298	20
45	9.507099	9.976318	9.530781	10.469219	15
50	9.508956	9.976103	9.532853	10.467147	10
55	9.510803	9.975887	9.534916	10.465084	5
60	9.512642	9.975670	9.536972	10.463028	0
	Co-sine.	Sine.	Co-tang.	Tangent.	M

71.

19.

M	Sine.	Co-sine.	Tangent.	Co-tang.	
0	9.512642	9.975670	9.536972	10.460028	60
5	9.514472	9.975452	9.539020	10.460980	55
10	9.516294	9.975233	9.541061	10.458939	50
15	9.518107	9.975013	9.543094	10.456906	45
20	9.519911	9.974792	9.545119	10.454881	40
25	9.521707	9.974570	9.547138	10.452862	35
30	9.523495	9.974347	9.549149	10.450851	30
35	9.525275	9.974122	9.551153	10.448847	25
40	9.527046	9.973897	9.553149	10.446851	20
45	9.528810	9.973971	9.555139	10.444861	15
50	9.530565	9.973444	9.557121	10.442879	10
55	9.532312	9.973215	9.559097	10.440903	5
60	9.534052	9.972986	9.551066	10.438934	0
	Co-sine.	Sine.	Co-tang.	Tangent.	M

70.

Q 2

The Table of Sines and Tangents.

20.

M	Sine	Cofine.	Tangent.	Co-tang.	
0	9.534052	9.972966	9.561066	10.438934	60
5	9.535783	9.972755	9.563028	10.436972	55
10	9.537507	9.972524	9.564983	10.435017	50
15	9.539223	9.972291	9.566932	10.433068	45
20	9.540931	9.972058	9.568873	10.431127	40
25	9.542632	9.971823	9.570809	10.429191	35
30	9.544325	9.971583	9.572738	10.427262	30
35	9.546011	9.971351	9.574660	10.425340	25
40	9.547689	9.971113	9.576576	10.423424	20
45	9.549360	9.970874	9.578486	10.421514	15
50	9.551024	9.970635	9.580389	10.419611	10
55	9.552680	9.970394	9.582286	10.417714	5
60	9.554329	9.970152	9.584177	10.415823	0
	Cofine.	Sine.	Co-tang.	Tangent.	M

69.

21.

M	Sine.	Co-sine.	Tangent.	Co-tang.	
0	9.554329	9.970152	9.584177	10.415823	60
5	9.555971	9.969909	9.586062	10.413938	55
10	9.557606	9.969665	9.587941	10.412059	50
15	9.559234	9.969420	9.589814	10.410186	45
20	9.560855	9.969173	9.591681	10.408319	40
25	9.562468	9.968926	9.593542	10.406458	35
30	9.564075	9.968678	9.595398	10.404602	30
35	9.565676	9.968429	9.597247	10.402753	25
40	9.567269	9.968178	9.599091	10.400909	20
45	9.568856	9.967927	9.600949	10.399071	15
50	9.570435	9.967674	9.602761	10.397239	10
55	9.572009	9.967421	9.604588	10.395412	5
60	9.573575	9.967166	9.606410	10.393590	0
	Co-sine.	Sine.	Co-tang.	Tangent.	M

68.

The table of Sines and Tangents.

22.

M	Sine	Co-sine.	Tangent.	Co-tang.	
0	9.573575	9.967166	9.606410	10.393590	60
5	9.575136	9.966910	9.608225	10.391775	55
10	9.576689	9.966653	9.610036	10.389964	50
15	9.578236	9.966395	9.611841	10.388159	45
20	9.579777	9.966136	9.613641	10.386359	40
25	9.581312	9.965876	9.615435	10.384565	35
30	9.582840	9.965615	9.617224	10.382776	30
35	9.584361	9.965353	9.619008	10.380992	25
40	9.585877	9.965090	9.620787	10.379213	20
45	9.587386	9.964826	9.622561	10.377439	15
50	9.588890	9.964560	9.624330	10.375670	10
55	9.590387	9.964294	9.626093	10.373907	5
60	9.591878	9.964026	9.627852	10.372148	0
	Co-sine.	Sine	Co-tang.	Tangent.	M

67.

23.

M	Sine	Co-sine.	Tangent.	Co-tang.	
0	9.591878	9.964026	9.627852	10.372148	60
5	9.593363	9.963757	9.629606	10.370394	55
10	9.594842	9.963488	9.631355	10.368645	50
15	9.596315	9.963217	9.633098	10.366902	45
20	9.597783	9.962945	9.634838	10.365162	40
25	9.599244	9.962672	9.636572	10.363428	35
30	9.600700	9.962398	9.638302	10.361698	30
35	9.602150	9.962123	9.640027	10.359973	25
40	9.603594	9.961846	9.641747	10.358253	20
45	9.605032	9.961569	9.643463	10.356537	15
50	9.606465	9.961290	9.645174	10.354826	10
55	9.607892	9.961011	9.640881	10.353119	5
60	9.609313	9.960730	9.648583	10.351417	0
	Co-sine.	Sine.	Co-tang.	Tangent.	M

66.

The Table of Sines and Tangents.

24.

M	Sine.	Co-line.	Tangent.	Co-tang.	
0	9.609313	9.960730	9.648583	10.351417	60
5	9.610729	9.960448	9.650281	10.349719	55
10	9.612140	9.960165	9.651974	10.348026	50
15	9.613545	9.959882	9.653663	10.346337	45
20	9.614944	9.959596	9.655348	10.344652	40
25	9.616338	9.959310	9.657028	10.342972	35
30	9.617727	9.959023	9.658704	10.341296	30
35	9.619110	9.958734	9.660376	10.339624	25
40	9.620488	9.958445	9.662043	10.337957	20
45	9.621861	9.958154	9.663707	10.336293	15
50	9.623229	9.957863	9.665366	10.334634	10
55	9.624591	9.957570	9.667021	10.332979	5
60	9.625948	9.957276	9.668673	10.331327	0
	Co-line.	Sine.	Co-tang.	Tangent.	M

65.

25.

M	Sine.	Co-line.	Tangent.	Co-tang.	
0	9.625948	9.957276	9.668673	10.331327	60
5	9.627300	9.956981	9.670320	10.329680	55
10	9.628647	9.956684	9.671963	10.328037	50
15	9.629989	9.956387	9.673602	10.326398	45
20	9.631326	9.956089	9.675237	10.324763	40
25	9.632658	9.955789	9.676869	10.323131	35
30	9.633984	9.955488	9.678496	10.322504	30
35	9.635306	9.955186	9.680120	10.319880	25
40	9.636623	9.954883	9.681740	10.318260	20
45	9.637935	9.954579	9.683356	10.316644	15
50	9.639242	9.954274	9.684968	10.315032	10
55	9.640544	9.953968	9.686577	10.313423	5
60	9.641842	9.953660	9.688182	10.311818	0
	Co-line.	Sine.	Co-tang.	Tangent.	M

64.

The Table of Sines and Tangents.

26.

M	Sine.	Co-sine.	Tangent.	Co-tang.	
0	9.641842	9.953660	9.688182	10.311818	60
5	9.643135	9.953352	9.689783	10.310217	55
10	9.644423	9.953042	9.691381	10.308619	50
15	9.645706	9.952731	9.692975	10.307025	45
20	9.646984	9.952419	9.694566	10.305434	40
25	9.648258	9.952106	9.696153	10.303847	35
30	9.649527	9.951791	9.697736	10.302264	30
35	9.650792	9.951476	9.699316	10.300684	25
40	9.652052	9.951159	9.700893	10.299107	20
45	9.653308	9.950841	9.702466	10.297534	15
50	9.654558	9.950522	9.704036	10.295964	10
55	9.655805	9.950202	9.705603	10.294397	5
60	9.657047	9.959881	9.707166	10.292834	0
	Co-sine.	Sine.	Co-tang.	Tangent.	M

63.

27.

M	Sine.	Co-sine.	Tangent.	Co-tang.	
0	9.657047	9.949881	9.707166	10.292834	60
5	9.658284	9.949558	9.708726	10.291274	55
10	9.659517	9.949235	9.710282	10.289718	50
15	9.660746	9.948910	9.711836	10.288104	45
20	9.661970	9.948584	9.713386	10.286614	40
25	9.663190	9.948257	9.714933	10.285067	35
30	9.664406	9.947929	9.716477	10.283523	30
35	9.665617	9.947600	9.718017	10.281983	25
40	9.666824	9.947269	9.719555	10.280445	20
45	9.668027	9.946937	9.721089	10.278911	15
50	9.669225	9.946604	9.722621	10.277379	10
55	9.670419	9.946270	9.724149	10.275851	5
60	9.671609	9.945935	9.725674	10.274326	0
	Co-sine.	Sine.	Co-tang.	Tangent.	M

62.

The Table of Sines and Tangents.

28.

M	Sine.	Co-sine.	Tangent.	Co-tang.	
0	9.671609	9.945935	9.725674	10.274326	00
5	9.672795	9.945598	9.727197	10.272803	55
10	9.673977	9.945261	9.728716	10.271284	50
15	9.675155	9.944922	9.730233	10.269767	45
20	9.676328	9.944582	9.731746	10.268254	40
25	9.677498	9.944241	9.733257	10.266743	35
30	9.678663	9.943899	9.734764	10.265236	30
35	9.679824	9.943555	9.736269	10.263731	25
40	9.680982	9.943210	9.737771	10.262229	20
45	9.682135	9.942864	9.739271	10.260729	15
50	9.683284	9.942517	9.740767	10.259233	10
55	9.684430	9.942169	9.742261	10.257739	5
60	9.685571	9.941819	9.743752	10.256248	0
	Co sine.	Sine.	Co tang.	Tangent.	vi

61.

29.

M	Sine.	Co sine.	Tangent.	Co-tang.	
0	9.685571	9.941819	9.743751	10.256248	00
5	9.686709	9.941459	9.745240	10.254760	55
10	9.687843	9.941117	9.746726	10.253274	50
15	9.688972	9.940763	9.748209	10.251791	45
20	9.690098	9.940409	9.749689	10.250311	40
25	9.691220	9.940054	9.751167	10.248833	35
30	9.692339	9.939697	9.752642	10.247358	30
35	9.693453	9.939339	9.754114	10.245885	25
40	9.694564	9.938980	9.755585	10.244415	20
45	9.695671	9.938619	9.757052	10.242948	15
50	9.696775	9.938258	9.758517	10.241483	10
55	9.697874	9.937895	9.759979	10.240021	5
60	9.698970	9.937531	9.761439	10.238561	0
	Co-sine.	Sine.	Co-tang.	Tangent.	M

60.

The Table of Sines and Tangents.

30.

M	Sine.	Co-fine.	Tangent	Co-tang.	
0	9 698970	9.937531	9.761439	10.238561	60
5	9.700062	9.937165	9.762897	10.237103	55
10	9.701151	9.936799	9.764352	10.235648	50
15	9.702236	9.936431	9.765805	10.234195	45
20	9.703317	9.936062	9.767255	10.232745	40
25	9.704395	9.935692	9.768703	10.231297	35
30	9.705469	9.935320	9.770148	10.229852	30
35	9.706539	9.934948	9.771592	10.228408	25
40	9.707606	9.934574	9.773033	10.226967	20
45	9.708670	9.934199	9.774471	10.225529	15
50	9.709730	9.933822	9.775908	10.224092	10
55	9.710786	9.933445	9.777342	10.222658	5
60	9.711839	9.933066	9.778774	10.221226	0
	Co-fine.	Sine.	Co tang.	Tangent.	M

59.

31.

M	Sine.	Co-fine.	Tangent.	Co-tang.	
0	9.711839	9.933066	9.778774	10.221226	60
5	9.712889	9.932685	9.780203	10.219797	55
10	9.713935	9.932304	9.781631	10.218369	50
15	9.714978	9.931921	9.783056	10.216944	45
20	9.716017	9.931537	9.784479	10.215521	40
25	9.717053	9.931152	9.785900	10.214100	35
30	9.718085	9.930766	9.787319	10.212681	30
35	9.719114	9.930378	9.788736	10.211264	25
40	9.720140	9.929989	9.790151	10.209849	20
45	9.721162	9.929599	9.791563	10.208437	15
50	9.722181	9.929207	9.792974	10.207026	10
55	9.723197	9.928815	9.794383	10.205617	5
60	9.724210	9.928420	9.795789	10.204211	0
	Co-fine.	Sine.	Co-tang	Tangent.	M

58.

The Table of Sines and Tangents.

32.

M	Sine.	Co-sine.	Tangent.	Co-tang.	
0	9.724210	9.928420	9.795789	10.204211	60
5	9.725219	9.928025	9.797194	10.202806	55
10	9.726225	9.927629	9.798596	10.201404	50
15	9.727228	9.927231	9.799997	10.200003	45
20	9.728227	9.926831	9.801396	10.198604	40
25	9.729223	9.926431	9.802792	10.197208	35
30	9.720217	9.926029	9.804187	10.195812	30
35	9.731206	9.925626	9.805580	10.194420	25
40	9.732193	9.925222	9.806971	10.193029	20
45	9.733177	9.924816	9.808361	10.191639	15
50	9.734157	9.924409	9.809748	10.190252	10
55	9.735135	9.924001	9.811134	10.188866	5
60	9.736109	9.923591	9.812517	10.187483	0
	Co-sine.	Sine.	Co-tang.	Tangent.	M

57.

33.

M	Sine.	Co-sine.	Tangent.	Co-tang.	
0	9.736109	9.923591	9.812571	10.187483	60
5	9.737080	9.923181	9.813899	10.186101	55
10	9.738048	9.922769	9.815280	10.184720	50
15	9.739013	9.922355	9.816658	10.183342	45
20	9.739975	9.921940	9.818035	10.181965	40
25	9.740934	9.921524	9.819410	10.180590	35
30	9.741889	9.921107	9.820783	10.179217	30
35	9.742842	9.920688	9.822154	10.177846	25
40	9.743792	9.920268	9.823524	10.176476	20
45	9.744739	9.919846	9.824893	10.175107	15
50	9.745683	9.919424	9.826259	10.173741	10
55	9.746624	9.919000	9.827624	10.172376	5
60	9.747562	9.918574	9.828987	10.171013	0
	Co-sine.	Sine.	Co-tang.	Tangent.	M

56.

The Table of Sines and Tangents.

34.

M	Sine.	Co-sine.	Tangent.	Co-tang.	
0	9.747562	9.918574	9.828987	10.171013	60
5	9.748497	9.918147	9.830349	10.169651	55
10	9.749429	9.917719	9.831709	10.168291	50
15	9.750358	9.917290	9.833068	10.166932	45
20	9.751284	9.916859	9.834425	10.165575	40
25	9.752208	9.916427	9.835780	10.164220	35
30	9.753128	9.915994	9.837134	10.162866	30
35	9.754046	9.915559	9.838487	10.161513	25
40	9.754960	9.915123	9.839838	10.160162	20
45	9.755872	9.914685	9.841187	10.158813	15
50	9.756782	9.914246	9.842535	10.157465	10
55	9.757688	9.913806	9.843882	10.156118	5
60	9.758591	9.913365	9.845227	10.154773	0
	Co-sine.	Sine.	Co-tang.	Tangent.	M

55.

35.

M	Sine.	Co-sine.	Tangent.	Co-tang.	M
0	9.758591	9.913365	9.845227	10.154773	60
5	9.759492	9.912922	9.846570	10.153430	55
10	9.760390	9.912477	9.847913	10.152087	50
15	9.761285	9.912031	9.849254	10.150746	45
20	9.762177	9.911584	9.850593	10.149407	40
25	9.763067	9.911136	9.851931	10.148069	35
30	9.763954	9.910686	9.853268	10.146732	30
35	9.764838	9.910235	9.854603	10.145397	25
40	9.765720	9.909782	9.855938	10.144062	20
45	9.766598	9.909328	9.857270	10.142730	15
50	9.767475	9.908873	9.858602	10.141398	10
55	9.768348	9.908416	9.859932	10.140068	5
60	9.769219	9.907958	9.861261	10.138730	0
	Co-sine.	Sine.	Co-tang.	Tangent	

54.

The Table of Sines and Tangents.

36.

M	Sine.	Co-sine.	Tangent.	Co-tang.	
0	9.769219	9.907758	9.861261	10.138759	60
5	9.770087	9.907498	9.862589	10.137411	55
10	9.770952	9.907037	9.863915	10.136085	50
15	9.771815	9.906575	9.865240	10.134760	45
20	9.772675	9.906111	9.866564	10.133436	40
25	9.773533	9.905645	9.867887	10.132133	35
30	9.774388	9.905179	9.869209	10.130791	30
35	9.775240	9.904711	9.870529	10.129471	25
40	9.776090	9.904241	9.871849	10.128151	20
45	9.776937	9.903770	9.873167	10.126833	15
50	9.777781	9.903298	9.874484	10.125561	10
55	9.778624	9.902824	9.875800	10.124200	5
60	9.779463	9.902349	9.877114	10.122886	0
	Co-sine.	Sine.	Co-tang.	Tangent.	M

53.

37.

M	Sine.	Co-sine.	Tangent.	Co-tang.	
0	9.779463	9.902349	9.877114	10.122886	60
5	9.780300	9.901872	9.878428	10.121572	55
10	9.781134	9.901394	9.879741	10.120259	50
15	9.781966	9.900914	9.881052	10.118948	45
20	9.782796	9.900433	9.882363	10.117637	40
25	9.783623	9.899951	9.883672	10.116328	35
30	9.784447	9.899467	9.884980	10.115020	30
35	9.785269	9.898981	9.886288	10.113712	25
40	9.786089	9.898494	9.887594	10.112406	20
45	9.786906	9.898006	9.888900	10.111100	15
50	9.787720	9.897516	9.890204	10.109796	10
55	9.788532	9.897025	9.891507	10.108493	5
60	9.789342	9.896530	9.892810	10.107190	0
	Co-sine.	Sine.	Co tang.	Tangent.	M

52.

The Table of Sines and Tangents.

38.

M	Sine.	Co-fine.	Tangent.	Co tang.	
0	9.789342	9.896532	9.892810	10.107190	60
5	9.790149	9.896038	9.894111	10.105889	55
10	9.790954	9.895542	9.895412	10.104588	50
15	9.791757	9.895045	9.896712	10.103288	45
20	9.792557	9.89454	9.898010	10.101990	40
25	9.793354	9.894046	9.899308	10.100692	35
30	9.794150	9.893544	9.900605	10.099395	30
35	9.794942	9.893041	9.901901	10.098099	25
40	9.795733	9.892536	9.903197	10.096803	20
45	9.796521	9.892030	9.904491	10.095509	15
50	9.797307	9.891523	9.905785	10.094215	10
55	9.798091	9.891013	9.907077	10.092923	5
60	9.798872	9.890503	9.908369	10.091631	0
	Co-fine.	Sine.	Co-tang.	Tangent.	M

51.

39.

M	Sine.	Co-fine.	Tangent.	Co-tang	
0	9.798872	9.890503	9.908369	10.091631	60
5	9.799651	9.889990	9.909660	10.090340	55
10	9.800427	9.889477	9.910951	10.089049	50
15	9.801201	9.888961	9.912240	10.087760	45
20	9.801973	9.888444	9.913529	10.086471	40
25	9.802743	9.887926	9.914817	10.085183	35
30	9.803511	9.887406	9.916104	10.083895	30
35	9.804276	9.886885	9.917391	10.082609	25
40	9.805039	9.886362	9.918677	10.081323	20
45	9.805799	9.885837	9.919962	10.080038	15
50	9.806557	9.885311	9.921247	10.078753	10
55	9.807314	9.884783	6.922530	10.077470	5
60	9.808067	9.884254	6.923814	10.076186	0
	Co-fine.	Sine.	Co-tang.	Tangent.	M

50.

The Table of Sines and Tangents.

40.

M	Sine.	Co-sine.	Tangent.	Co-tang.	
0	9.808067	9.884254	9.923814	10.076186	60
5	9.808819	9.883723	9.925096	10.074904	55
10	9.809569	9.883191	9.926378	10.073622	50
15	9.810316	9.882657	9.927659	10.072341	45
20	9.811061	9.882121	9.928940	10.071060	40
25	9.811804	9.881584	9.930220	10.069780	35
30	9.812544	9.881046	9.931499	10.068501	30
35	9.813283	9.880505	9.932778	10.067222	25
40	9.814019	9.879063	9.934056	10.065944	20
45	9.814753	9.879420	9.935333	10.064667	15
50	9.815485	9.878875	9.936611	10.063389	10
55	9.816215	9.878328	9.937887	10.062113	5
60	9.816943	9.877780	9.939163	10.060837	0
	Co-sine.	Sine.	Co-tang.	Tangent.	M

49.

41.

M	Sine.	Co-sine.	Tangent.	Co-tang.	
0	9.816943	9.877780	9.939163	10.060837	60
5	9.817668	9.877230	9.940439	10.059561	55
10	9.818392	9.876078	9.941713	10.058287	50
15	9.819113	9.876125	9.942988	10.057012	45
20	9.819832	9.875571	9.944262	10.055738	40
25	9.820550	9.875014	9.945535	10.054465	35
30	9.821265	9.874456	9.946808	10.053192	30
35	9.821977	9.873896	9.948081	10.051919	25
40	9.822688	9.873335	9.949353	10.050647	20
45	9.823397	9.872772	9.950625	10.049375	15
50	9.824104	9.872208	9.951896	10.048104	10
55	9.824808	9.871641	9.953167	10.046833	5
60	9.825511	9.871073	9.954437	10.045563	0
	Co-sine.	Sine.	Co-tang.	Tangent.	M

48.

The Table of Sines and Tangents.

42.

M	Sine.	Co-sine.	Tangent.	Co-tang.	
0	9.825511	9.871073	9.954437	10.045503	60
5	9.826211	9.870504	9.955708	10.044292	55
10	9.826910	9.869933	9.956977	10.043023	50
15	9.827606	9.869360	9.958247	10.041753	45
20	9.82830	9.868785	9.959516	10.040484	40
25	9.828993	9.868209	9.960784	10.039216	35
30	9.829683	9.867631	9.962052	10.037948	30
35	9.830372	9.867051	9.963320	10.036680	25
40	9.831058	9.866470	9.964588	10.035412	20
45	9.831742	9.865887	9.965855	10.034145	15
50	9.832425	9.865302	9.967123	10.032877	10
55	9.833105	9.864716	9.968389	10.031611	5
60	9.833783	9.864127	9.969656	10.030344	0
	Co-sine.	Sine.	Co-tang.	Tangent.	M

47.

43.

M	Sine.	Co-sine.	Tangent.	Co-tang.	
0	9.833783	9.864127	9.969656	10.030344	60
5	9.834460	9.863538	9.970922	10.029078	55
10	9.835134	9.862946	9.972188	10.027812	50
15	9.835807	9.862353	9.973454	10.026546	45
20	9.836377	9.861758	9.974720	10.025280	40
25	9.837146	9.861161	9.975985	10.024015	35
30	9.837812	9.860562	9.977250	10.022750	30
35	9.838477	9.859962	9.978515	10.021485	25
40	9.839140	9.859360	9.979780	10.020220	20
45	9.840800	9.858756	9.981044	10.018956	15
50	9.840459	9.858151	9.982309	10.017691	10
55	9.841116	9.857543	9.983573	10.016427	5
60	9.841771	9.856934	9.984837	10.015163	0
	Co-sine.	Sine.	Co-tang.	Tangent.	M

46.

The Table of Sines and Tangents.

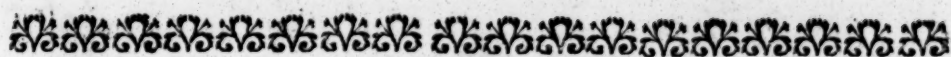
44.

M	Sine.	Co-sine.	Tangent.	Co-tang.	
0	9.841771	9.856934	9.984837	10.015163	60
5	9.842424	9.856323	9.986101	10.013899	55
10	9.843076	9.855711	9.987365	10.012635	50
15	9.843725	9.855096	9.988629	10.011371	45
20	9.844372	9.854480	9.989893	10.010107	40
25	9.845018	9.853862	9.991156	10.008844	35
30	9.845662	9.853242	9.992420	10.007580	30
35	9.846304	9.852620	9.993683	10.006317	25
40	9.846944	9.851997	9.994947	10.005053	20
45	9.847582	9.851372	9.996210	10.003790	15
50	9.848218	9.850745	9.997473	10.002527	10
55	9.848852	9.850116	9.998737	10.001263	5
60	9.849485	9.849485	10.000000	10.000000	0
	Co-sine.	Sine.	Co-tang.	Tangent.	M

45.



A TABLE

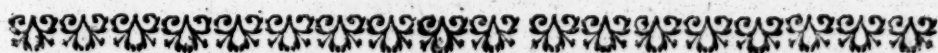


A

T A B L E

O F

Logarithm Numbers.



R

A Table of Logarithms.

N.	Logarith.	N.	Logarith.	N.	Logarith.
1	0.000000	34	1.531479	67	1.826075
2	0.301030	35	1.544068	68	1.832509
3	0.477121	36	1.556303	69	1.838849
4	0.602060	37	1.568202	70	1.845098
5	0.698970	38	1.579783	71	1.851258
6	0.778151	39	1.591664	72	1.857332
7	0.845098	40	1.602060	73	1.863323
8	0.903090	41	1.612784	74	1.869232
9	0.954242	42	1.923249	75	1.875061
10	1.000000	43	1.633468	76	1.880813
11	1.041393	44	1.643452	77	1.886491
12	1.079181	45	1.653212	78	1.892094
13	1.113943	46	1.662758	79	1.897627
14	1.146128	47	1.672098	80	1.903090
15	1.176091	48	1.681241	81	1.908485
16	1.204120	49	1.690196	82	1.913814
17	1.230419	50	1.698970	83	1.919078
18	1.255272	51	1.707570	84	1.924279
19	1.278753	52	1.716003	85	1.929419
20	1.301230	53	1.724276	86	1.934498
21	1.322219	54	1.732394	87	1.939519
22	1.342422	55	1.740362	88	1.944482
23	1.361728	56	1.748188	89	1.949390
24	1.380211	57	1.755875	90	1.954242
25	1.397940	58	1.763428	91	1.959041
26	1.414973	59	1.770852	92	1.963788
27	1.431364	60	1.778151	93	1.968483
28	1.447158	61	1.785330	94	1.973128
29	1.462398	62	1.792391	95	1.977723
30	1.477121	63	1.799340	96	1.982271
31	1.491361	64	1.806180	97	1.980772
32	1.505150	65	1.812913	98	1.991226
33	1.518514	96	1.819544	99	1.995635
34	1.531479	67	1.826075	100	2.000000

N.	Logarith.	N.	Logarith.	N.	Logarith.
101	2.004321	134	2.127105	167	2.222716
102	2.008600	135	2.130334	168	2.225309
103	2.012837	136	2.133539	169	2.227887
104	2.017033	137	2.136721	170	2.230449
105	2.021189	138	2.139879	171	2.232996
106	2.025306	139	2.143015	172	2.235528
107	2.029384	140	2.146128	173	2.238046
108	2.033424	141	2.149219	174	2.240549
109	2.037426	142	2.152288	175	2.243038
110	2.041393	143	2.155336	176	2.245513
111	2.045323	144	2.158362	177	2.247973
112	2.049218	145	2.161368	178	2.250420
113	2.053078	146	2.164353	179	2.252853
114	2.056905	147	2.167317	180	2.255273
115	2.060698	148	2.170262	181	2.257679
116	2.064458	149	2.173186	182	2.260071
117	2.068186	150	2.176091	183	2.262451
118	2.071882	151	2.178977	184	2.264818
119	2.075547	152	2.181844	185	2.267172
120	2.079181	153	2.184691	186	2.269513
121	2.082785	154	2.187521	187	2.271842
122	2.086359	155	2.190332	188	2.274158
123	2.089905	156	2.193125	189	2.276462
124	2.093422	157	2.195899	190	2.278754
125	2.096910	158	2.198657	191	2.281033
126	2.100371	159	2.201397	192	2.283301
127	2.103804	160	2.204110	193	2.285557
128	2.107209	161	2.206826	194	2.287802
129	2.110589	162	2.209515	195	2.290035
130	2.113943	163	2.212187	196	2.292256
131	2.117271	164	2.214844	197	2.294466
132	2.120574	165	2.217484	198	2.296665
133	2.123852	166	2.220108	199	2.298853
134	2.127105	167	2.222716	200	2.301029

N.	Logarith.	N.	Logarith.	N.	Logarith.
201	2.303196	234	2.369216	267	2.426511
202	2.305351	235	2.371068	268	2.428135
203	2.307496	236	2.372912	269	2.429752
204	2.309630	237	2.374748	270	2.421364
205	2.311754	238	2.376577	271	2.432469
206	2.313867	239	2.378398	272	2.434569
207	2.315970	240	2.380211	273	2.436163
208	2.318063	241	2.382017	274	2.437751
209	2.320146	242	2.383815	275	2.439333
210	2.322219	243	2.385606	276	2.440909
211	2.324282	244	2.387389	277	2.442479
212	2.326336	245	2.389166	278	2.444045
213	2.328379	246	2.390935	279	2.445604
214	2.330414	247	2.392697	280	2.447158
215	2.332438	248	2.394452	281	2.448706
216	2.334454	249	2.396199	282	2.450249
217	2.336459	250	2.397940	283	2.451786
218	2.338456	251	2.399674	284	2.453318
219	2.340444	252	2.401401	285	2.454845
220	2.342422	253	2.403121	286	2.456366
221	2.344392	254	2.404834	287	2.457889
222	2.346353	255	2.406540	288	2.459392
223	2.348305	256	2.408239	289	2.460898
224	2.350248	257	2.409933	290	2.462398
225	2.352183	258	2.411619	291	2.463893
226	2.354108	259	2.413299	292	2.465383
227	2.356026	260	2.414973	293	2.466868
228	2.357935	261	2.416641	294	2.468347
229	2.359835	262	2.418301	295	2.469822
230	2.361728	263	2.419956	296	2.471292
231	2.363612	264	2.421604	297	2.472756
232	2.365488	265	2.423246	298	2.474216
233	2.367356	266	2.424882	299	2.475671
234	2.369216	267	2.426511	300	2.477121

N.	Logarith.	N.	Logarith.	N.	Logarith.
301	2.478566	334	2.523746	367	2.564666
302	2.480007	335	2.525045	368	2.565848
303	2.481443	336	2.526339	369	2.567026
304	2.482874	337	2.527629	370	2.568202
305	2.484299	338	2.528916	371	2.569374
306	2.485721	339	2.530199	372	2.570543
307	2.487138	340	2.531479	373	2.571709
308	2.488551	341	2.532754	374	2.572872
309	2.489958	342	2.534026	375	2.574031
310	2.491362	343	2.535294	376	2.575188
311	2.492760	344	2.536558	377	2.576341
312	2.494155	345	2.537819	378	2.577492
313	2.495544	346	2.539076	379	2.578639
314	2.496929	347	2.540329	380	2.579784
315	2.498311	348	2.541579	381	2.580925
316	2.499687	349	2.542825	382	2.582063
317	2.501059	350	2.544008	383	2.583199
318	2.502427	351	2.545307	384	2.584331
319	2.503791	352	2.546543	385	2.585461
320	2.505149	353	2.547775	386	2.586587
321	2.506505	354	2.549003	387	2.587711
322	2.507856	355	2.550228	388	2.588832
323	2.509203	356	2.551449	389	2.589949
324	2.510545	357	2.552668	390	2.591065
325	2.511883	358	2.553883	391	2.592177
326	2.513218	359	2.555094	392	2.593286
327	2.514548	360	2.556303	393	2.594393
328	2.515874	361	2.557507	394	2.595496
329	2.517196	362	2.558709	395	2.596597
330	2.518514	363	2.559907	396	2.597695
331	2.519828	364	2.561101	397	2.598790
332	2.521138	365	2.562293	398	2.599883
333	2.522444	366	2.563481	399	2.600973
334	2.523746	367	2.564666	400	2.602059

N.	Logarith.	N.	Logarith.	N.	Logarith.
401	2.603144	434	2.637489	467	2.669317
402	2.604226	435	2.638489	468	2.670246
403	2.605305	436	2.639486	469	2.671173
404	2.606381	437	2.640481	470	2.672098
405	2.607455	438	2.641475	471	2.673021
406	2.608526	439	2.642465	472	2.673942
407	2.609594	440	2.643453	473	2.674861
408	2.610660	441	2.644439	474	2.675778
409	2.611723	442	2.645422	475	2.676694
410	2.612784	443	2.646404	476	2.677607
411	2.613842	444	2.647383	477	2.678518
412	2.614897	445	2.648360	478	2.679428
413	2.615950	446	2.649335	479	2.680336
414	2.617000	447	2.650308	480	2.681241
415	2.618048	448	2.651278	481	2.682145
416	2.619093	449	2.652246	482	2.683047
417	2.620136	450	2.653213	483	2.683947
418	2.621176	451	2.654177	484	2.684845
419	2.622214	452	2.655138	485	2.685742
420	2.623249	453	2.656098	486	2.686636
421	2.624282	454	2.657056	487	2.687529
422	2.625312	455	2.658011	488	2.688419
423	2.626340	456	2.658965	489	2.689309
424	2.627366	457	2.659916	490	2.690196
425	2.628389	458	2.660865	491	2.691081
426	2.629409	459	2.661813	492	2.691965
427	2.630428	460	2.662758	493	2.692847
428	2.631444	461	2.663701	494	2.693727
429	2.632457	462	2.664642	495	2.694605
430	2.633468	463	2.665581	496	2.695482
431	2.634477	464	2.666518	497	2.696356
432	2.635484	465	2.667453	498	2.697229
433	2.636488	466	2.668386	499	2.698101
434	2.637489	467	2.669317	500	2.698970

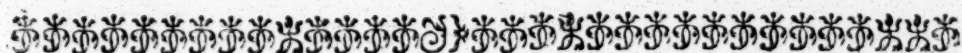
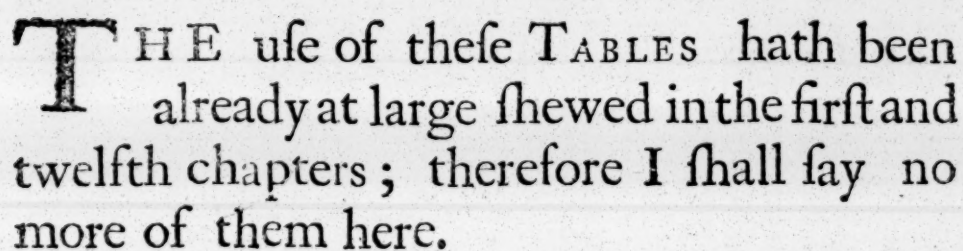
N.	Logarith.	N.	Logarith.	N.	Logarith.
501	2.699838	534	2.727541	567	2.753583
502	2.700704	535	2.728354	568	2.754348
503	2.701568	536	2.729165	569	2.755112
504	2.702430	537	2.729974	570	2.755875
505	2.703291	538	2.730782	571	2.756636
506	2.704151	539	2.731589	572	2.757396
507	2.705008	540	2.732394	573	2.758155
508	2.705863	541	2.733197	574	2.758912
509	2.706718	542	2.733999	575	2.759668
510	2.707570	543	2.734799	576	2.760422
511	2.708421	544	2.735599	577	2.761176
512	2.709269	545	2.736397	578	2.761928
513	2.710117	546	2.737192	579	2.762679
514	2.710963	547	2.737987	580	2.763428
515	2.711807	548	2.738781	581	2.764176
516	2.712649	549	2.739572	582	2.764923
517	2.713491	550	2.740363	583	2.765669
518	2.714329	551	2.741152	584	2.766413
519	2.715167	552	2.741939	585	2.767156
520	2.716003	553	2.742725	586	2.767898
521	2.716838	554	2.743509	587	2.768638
522	2.717671	555	2.744293	588	2.769377
523	2.718502	556	2.745075	589	2.770115
524	2.719331	557	2.745855	590	2.770852
525	2.720159	558	2.746634	591	2.771587
526	2.720986	559	2.747412	592	2.772322
527	2.721811	560	2.748188	593	2.773055
528	2.722634	561	2.748963	594	2.773786
529	2.723456	562	2.749736	595	2.774517
530	2.724276	563	2.750508	596	2.775246
531	2.725095	564	2.751279	597	2.775974
532	2.725912	565	2.752048	598	2.776701
533	2.726727	566	2.752816	599	2.777427
534	2.727541	567	2.753583	600	2.778151

N.	Logarith.	N.	Logarith.	N.	Logarith.
601	2.778874	634	2.802089	667	2.824126
602	2.779596	635	2.802774	668	2.824776
603	2.780317	636	2.803457	669	2.825426
604	2.781037	637	2.804139	670	2.826075
605	2.781755	638	2.804821	671	2.826723
606	2.782473	639	2.805501	672	2.827369
607	2.783189	640	2.806179	673	2.828015
608	2.783904	641	2.806858	674	2.828659
609	2.784617	642	2.807535	675	2.829304
610	2.785329	643	2.808211	676	2.829947
611	2.786041	644	2.808886	677	2.830589
612	2.786751	645	2.809559	678	2.831229
613	2.787460	646	2.810233	679	2.831869
614	2.788164	647	2.810904	680	2.832509
615	2.788875	648	2.811575	681	2.833147
616	2.789581	649	2.812245	682	2.833784
617	2.790285	650	2.812913	683	2.834421
618	2.790988	651	2.813581	684	2.835056
619	2.791691	652	2.814248	685	2.835691
620	2.792302	653	2.814913	686	2.836324
621	2.793092	654	2.815578	687	2.836957
622	2.793791	655	2.816241	688	2.837588
623	2.794488	656	2.816904	689	2.838219
624	2.795185	657	2.817565	690	2.838849
625	2.795880	658	2.818226	691	2.839478
626	2.796574	659	2.818885	692	2.840106
627	2.797268	660	2.819543	693	2.840733
628	2.797959	661	2.820201	694	2.841359
629	2.798651	662	2.820858	695	2.841985
630	2.799341	663	2.821514	696	2.842609
631	2.800029	664	2.822168	697	2.843233
632	2.800717	665	2.822822	698	2.843855
633	2.801404	666	2.823474	699	2.844477
634	2.802089	667	2.824126	700	2.845098

N.	Logarith.	N.	Logarith.	N.	Logarith.
701	2.845718	734	2.865696	767	2.884795
702	2.846337	735	2.866287	768	2.885361
703	2.846955	736	2.866878	769	2.885926
704	2.847573	737	2.867467	770	2.886491
705	2.848189	738	2.868056	771	2.887054
706	2.848805	739	2.868643	772	2.887617
707	2.849419	740	2.869232	773	2.888179
708	2.850033	741	2.869818	774	2.888741
709	2.850646	742	2.870404	775	2.889302
710	2.851258	743	2.870989	776	2.889862
711	2.851869	744	2.871573	777	2.890421
712	2.852479	745	2.872156	778	2.890979
713	2.853089	746	2.872739	779	2.891537
714	2.853698	747	2.873321	780	2.892095
715	2.854306	748	2.873902	781	2.892651
716	2.854913	749	2.874482	782	2.893207
717	2.855519	750	2.875061	783	2.893762
718	2.856124	751	2.875639	784	2.894316
719	2.856729	752	2.876218	785	2.894869
720	2.857332	753	2.876795	786	2.895423
721	2.857935	754	2.877371	787	2.895975
722	2.858537	755	2.877947	788	2.896526
723	2.859138	756	2.878522	789	2.897077
724	2.859739	757	2.879096	790	2.897627
725	2.860338	758	2.879669	791	2.898176
726	2.860937	759	2.880242	792	2.898725
727	2.861534	760	2.880814	793	2.899273
728	2.862131	761	2.881385	794	2.899821
729	2.862728	762	2.881955	795	2.900367
730	2.863323	763	2.882525	796	2.900913
731	2.863917	764	2.883093	797	2.901458
732	2.864511	765	2.883661	798	2.902003
733	2.865104	766	2.884229	799	2.902547
734	2.865696	767	2.884795	800	2.903089

N.	Logarith.	N.	Logarith.	N.	Logarith.
801	2.903633	834	2.921166	867	2.938019
802	2.904174	835	2.921686	868	2.938519
803	2.904716	836	2.922206	869	2.939019
804	2.905256	837	2.922725	870	2.939519
805	2.905796	838	2.923244	871	2.940018
806	2.906335	839	2.923762	872	2.940516
807	2.906874	840	2.924279	873	2.941014
808	2.907411	841	2.924796	874	2.941511
809	2.907949	842	2.925312	875	2.942008
810	2.908485	843	2.925828	876	2.942504
811	2.909021	844	2.926342	877	2.942999
812	2.909556	845	2.926857	878	2.943495
813	2.910091	846	2.927370	879	2.943989
814	2.910624	847	2.927883	880	2.944483
815	2.911158	848	2.928396	881	2.944976
816	2.911690	849	2.928908	882	2.945468
817	2.912222	850	2.929419	883	2.945961
818	2.912753	851	2.929929	884	2.946452
819	2.913284	852	2.930439	885	2.946943
820	2.913814	853	2.930949	886	2.947434
821	2.914343	854	2.931458	887	2.947924
822	2.914872	855	2.931966	888	2.948413
823	2.915399	856	2.932474	889	2.948902
824	2.915927	857	2.932981	890	2.949390
825	2.916454	858	2.933487	891	2.949878
826	2.916980	859	2.933993	892	2.950365
827	2.917506	860	2.934498	893	2.950851
828	2.918030	861	2.935003	894	2.951338
829	2.918555	862	2.935507	895	2.951823
830	2.919078	863	2.936011	896	2.952308
831	2.919601	864	2.936514	897	2.952792
832	2.920123	865	2.937016	898	2.953276
833	2.920645	866	2.937518	899	2.953759
834	2.921166	867	2.938019	900	2.954243

N.	Logarith.	N.	Logarith.	N.	Logarith.
901	2.954725	934	2.970347	967	2.985426
902	2.955207	935	2.970812	968	2.985875
903	2.955688	936	2.971276	969	2.986324
904	2.956198	937	2.971739	970	2.986772
905	2.956649	938	2.972203	971	2.987219
906	2.957128	939	2.972669	972	2.987666
907	2.957607	940	2.973128	973	2.988113
908	2.958086	941	2.973589	974	2.988559
909	2.958564	942	2.974050	975	2.989005
910	2.959041	943	2.974512	976	2.989449
911	2.959518	944	2.974972	977	2.989895
912	2.959995	945	2.975432	978	2.990339
913	2.960471	946	2.975891	979	2.990783
914	2.960946	947	2.976349	980	2.991226
915	2.961421	948	2.976808	981	2.991669
916	2.961895	949	2.977266	982	2.992111
917	2.962369	950	2.977724	983	2.992554
918	2.962843	951	2.978181	984	2.992995
919	2.963315	952	2.978637	985	2.993436
920	2.963788	953	2.979093	986	2.993877
921	2.964259	954	2.979548	987	2.994317
922	2.964731	955	2.980003	988	2.994756
923	2.965202	956	2.980458	989	2.995196
924	2.965672	957	2.980912	990	2.995635
925	2.966142	958	2.981366	991	2.996074
926	2.966611	959	2.981819	992	2.996512
927	2.967079	960	2.982271	993	2.996949
928	2.967548	961	2.982723	994	2.997386
929	2.968016	962	2.983175	995	2.997823
930	2.968483	963	2.983626	996	2.998250
931	2.968949	964	2.984077	997	2.998695
932	2.969416	965	2.984527	998	2.999130
933	2.969882	966	2.984977	999	2.999560
934	2.970347	967	2.985426	1000	350000



A N

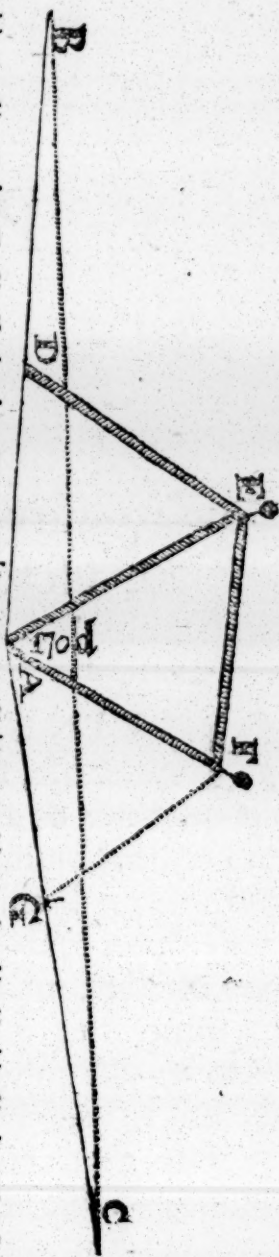
A P P E N D I X,

Shewing farther

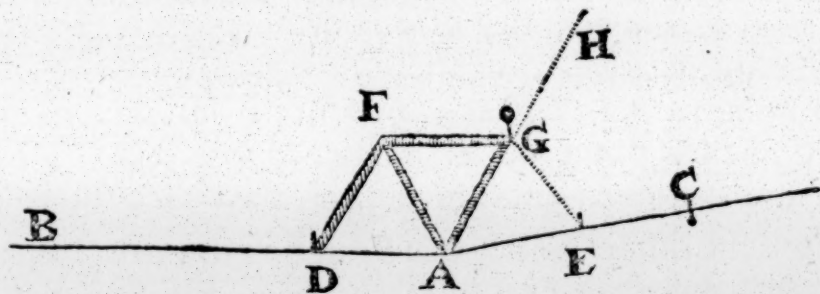
How to survey by the Chain only : with
an useful Table to that Purpose.

HAVING, in the sixth chapter of the foregoing Treatise, shewn a ready and easy way for taking the quantity of an angle in the field by the chain only, and understanding it has been approved of by surveyors and others, I think it not improper to say something more upon that subject in this place. And that this way of working may be practised with as much ease as by using the most costly instruments, there are two seeming difficulties must be removed. The first is, when the angle becomes very obtuse, or contains 170 degrees or more, then the subtending or chord-line will hardly be distinguishable between five or six degrees, there being but $\frac{1}{5}$ part of a link difference between 170 degrees and 171 degrees, and not above $\frac{1}{10}$ part between 178 and 179 degrees. To remedy which, you need not take the quantity of that angle at all, especially if it be an inward angle, but measure directly from B to C ; and when you come right against A, take an off-set (which
you

you may do with a rod or line only, as true as with a cross or other instrument) this off-set being put down in your field-book, will do the business when you come to protract, as well as if you had taken the angle in the field: but if that is not sufficient, or any other reason necessitate you to take the angle A, there place a strong stick in the angular point A, and putting the ring of the chain over it, stretch it out at full length, both in the line A B and A C; and where the end of the chain falls, there place sticks also, as at D and G. Remove your chain from A, and put the ring over the stick at D, and stretch it out towards E. Now you should have another chain, or a small line, (which you may carry in your pocket) exactly of the length of a chain, with a loop at each end; which put over the stick at A, and taking the other loop of the line in one hand, and the loose end of the chain in the other hand, go backward 'till both being stretched strait meet at E, then will D A E be an equilateral triangle, to which add another equilateral triangle by loosing the chain at D, and putting it over the stick at E, letting the line remain as it was fastened at A, and taking the loose ends again of the chain and line in your hands, go backwards as before, 'till both being stretched strait, meet in F. So have you formed two equilateral triangles, and D A F will contain 120 degrees. Lastly, with your chain measure the nearest distance F G, which suppose to be 84 links and a half; which sum look for in the following table, and right against it you will find



lateral triangles, one end of the chain hanging at A, stretch the other at full length over the stick at G, which will fall at H; then measuring the nearest distance between H and C, you will find it to be $84\frac{1}{2}$ links, against which in the table stand 50 degrees, which added to the angle D A G 120 degrees, make 170 degrees for the angle B A C. [See this figure.]



But if you had rather measure this angle, by first taking out a right one from it, proceed thus: [See the figure on the other side.] put one ring of your chain over the stick at the angular point A, and stretching out the chain, let the other end fall any where at pleasure, as at B or C; where stick a stick through the ring, and loosing that end at A, take it in your hand and stretching it strait, see in what part it will just touch the hedge A E; which will be at D, if the other end be at C; or at E, if the other end be at B; and there make a mark; which done, keeping the end of your chain in your hand, go backward from B or C, towards G or F, 'till your chain is strait; then moving yourself sideways to and fro, 'till you perceive your chain to lie in a strait line with B E or C D, at the end of it place a stick at F or G, from whence to A will be a line perpendicular to A E; wherefore from A set off one chain in that line, which will fall at H; and one chain upon the line A I, which falls at I, and measuring the distance H I, you will find it 128 links $\frac{3}{4}$ parts of a link, or 80 degrees; which added to the right angle, makes 170 degrees, which was the angle required.

Otherwise you may form a right angle, by fixing one end of the chain in the angular point, and the other end at

at 40 links distance in the hedge; then take 50 links in one hand, and 30 in the other, and stretch both parts strait, their meeting will constitute a right angle, it being well known that three lines in the proportion of 3, 4, and 5, will form a right-angled triangle.

Several other ways might be shewn to take a right angle in the field by the chain only, and also to measure the quantity of an obtuse angle; but omitting those, I shall only mention one way more, to take the quantity of an obtuse angle; which is as follows:

Let A be the angle required to be taken in the field; by the chain first from A, set off two chains, one to B, the other to C: then fixing one end of the chain in B, stretch the other directly in a strait line towards C, making a mark where the end falls, as at 7; measure the distance from 7 to A, which suppose 8 links $\frac{7}{10}$ parts of a link; look in the following TABLE for this number, and right against it, you will find 5 degrees; which dou-



bled (the angles A C 7 and A B 7 being equal, because the sides A B and A C are equal) makes 10 degrees; and subtracted from 180, leaves 170 for the angle at A required.

If the angle be an outward one, continue one of the lines, as D A to C, making A C one chain; also set off one chain upon the other line from A to B; then measure the distance B C, which suppose to be 17 links $\frac{4}{10}$ parts



of a link, and answers in the table to 10 degrees, which is the complement of the angle A to 180 degrees; therefore take 10 from 180, remains 170 for the outward angle D A B.

S

These

These examples, I apprehend, will remove the difficulty of measuring obtuse angles, and make the matter both plain and easy ; as for acute angles, and such obtuse ones as do not much exceed 90 degrees, you have the way to measure them already in the sixth chapter of the foregoing treatise, with sundry ways to measure a field with the chain only, to which I refer you.

It remains now to speak of the second seeming difficulty, which lies in the trouble of plotting after this way : to remove which you may have a protractor made with links on it instead of degrees, or both, if you please ; which the instrument-maker may soon do by the help of this table. Or you may very well use the common protractors ; for having a copy of this table in the field with you, you may at once note down the degrees of every angle, without mentioning the subtendents ; or if you only note down the subtendents in your field-book when you come home, you may at once take all the angles in degrees answerable to them, and so plot with an ordinary protractor, as at other times. I have extended the table only to 140 degrees ; for when an angle exceeds that number, your best way of measuring it, is by the method just now taught.

What has been already said, I presume, will sufficiently explain the following table, and the use thereof, therefore shall not trouble you with repetitions ; only desire you to remember, that the table is made for the radius of one chain, or 100 links ; and the subtendents, or chord lines, are in links, and decimal parts of a link : so that when you would use this table, you must set off but one chain from the angle (you desire to know the quantity of) on either hedge, and measuring the nearest distance between the two ends of the chains, a-cross from hedge to hedge, look for the number of links in the table that nearest distance contains, and right against it you will find the quantity of the angle as true, as if taken by the best Semicircle, Circumferentor or Theodolite.

EXAMPLE.

E X A M P L E.

I would know the quantity in degrees of an angle whose subtendent is (accounting one chain radius) 80 links: accordingly I look for 80 links in the table, and the nearest number to it is 79 links $\frac{7}{10}$ parts of a link, and right against it stands 47 degrees, wherefore I say that angle consists of 47 degrees and something more; and if you desire to know how much the remaining $\frac{3}{10}$ is you may see by the table, that in an angle of this magnitude one link and a half answers to a degree; so that $\frac{3}{10}$ parts of a link is just 12 minutes. The exact angle therefore is $47^{\circ} 12'$.

What has been said concerning measuring a field, or taking an angle by the chain only, either in the Appendix, or 6th chapter, may as well be applied to a pole or strait rod divided into 100 equal parts; every division of the rod answering to a link of the chain: and the table serves as well for a rod so divided as the chain, only observe in measuring the length of the lines, to call every 4 poles 1 chain, and every 4 divisions of the pole 1 link; then you may cast it up as if it had been measured by the chain. You may provide a rod made to shoot one part into another like a fishing-rod, to be used as a cane, in the head whereof place a small compass; and this instrument will be sufficient to survey any piece of ground with, without a horse-load of brass circles and semicircles, heavy ball-sockets, wooden tables and frames, and three-legged staffs, &c. which only serve to amuse the ignorant countryman, and make him more freely pay the surveyor.

*The TABLE of Chords, or Subtendents to the Radius of
one Chain of Gunter's or 100 Links.*

Degrees.	Links.	Tenths of a Link.	Degrees.	Links.	Tenths of a Link.	Degrees.	Links.	Tenths of a Link.	Degrees.	Links.	Tenths of a Link.
1	1	7	36	61	8	71	116	1	106	159	7
2	3	5	37	63	4	72	117	5	107	160	8
3	5	2	38	65	1	73	119	0	108	161	8
4	7	0	39	66	8	74	120	4	109	162	8
5	8	7	40	68	4	75	121	8	110	163	8
6	10	5	41	70	0	76	123	1	111	164	8
7	12	2	42	71	7	77	124	5	112	165	8
8	14	0	43	73	3	78	125	9	113	166	8
9	15	7	44	74	9	79	127	2	114	167	7
10	17	4	45	76	5	80	128	5	115	168	7
11	19	2	46	78	2	81	129	9	116	169	6
12	20	9	47	79	7	82	131	2	117	170	5
13	22	6	48	81	3	83	132	5	118	171	4
14	24	4	49	82	9	84	133	8	119	172	3
15	26	1	50	84	5	85	135	1	120	173	2
16	27	8	51	85	1	86	136	4	121	174	1
17	29	6	52	87	7	87	137	7	122	174	9
18	31	3	53	89	2	88	139	0	123	175	7
19	33	0	54	90	8	89	140	2	124	176	6
20	34	7	55	92	3	90	141	4	125	177	4
21	36	4	56	93	9	91	142	6	126	178	2
22	38	2	57	95	4	92	143	8	127	179	0
23	39	9	58	97	0	93	145	0	128	179	8
24	41	6	59	98	5	94	146	2	129	180	5
25	43	3	60	100	0	95	147	4	130	181	3
26	44	9	61	101	5	96	148	6	131	182	0
27	46	7	62	103	0	97	149	8	132	182	7
28	48	4	63	104	5	98	151	0	133	183	4
29	50	1	64	105	0	99	152	1	134	184	0
30	51	8	65	107	4	100	153	2	135	184	7
31	53	4	66	108	9	101	154	3	136	185	4
32	55	1	67	110	4	102	155	4	137	186	1
33	56	8	68	111	8	103	156	5	138	186	7
34	58	5	69	113	3	104	157	6	139	187	3
35	60	1	70	114	7	105	158	7	140	187	9

F I N I S.



